Lloyd's Register

Rules and Regulations for the Classification of Ships, July 2011

Notice No. 1

Effective Date of Latest Amendments:

See page 1

The contents of this Notice supercedes Part 3 Chapter 14 of the 2011 Rules

Issue date: July 2011

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RULES AND REGULATIONS FOR THE CLASSIFICATION OF SHIPS, *July 2011*

Notice No. 1

This Notice contains amendments within the following Sections of the *Rules and Regulations for the Classification of Ships, July 2011.* The amendments are effective on the dates shown:

Part	***Chapter***	***Section***	***Effective date***
3	14	Whole Chapter	1 July 2011

It will be noted that the amendments also include corrigenda, which are effective from the date of this Notice.

The *Rules and Regulations for the Classification of Ships, July 2011* are to be read in conjunction with this Notice No. 1. The status of the Rules is now:

Rules for Ships	Effective date:	July 2011
Notice No. 1	Effective dates:	1 July 2011

Part 3, Chapter 14

Cargo Securing Arrangements

Effective date 1 July 2011

■ *Section 1* General

1.1 Application

1.1.1 All cargo ships, regardless of tonnage, except those engaged solely in the carriage of either liquid or solid bulk cargoes are to be provided with a Cargo Securing Manual approved by the Flag Administration, as required by SOLAS 1974 (as amended). Sections 2, 4, 7 (if applicable) and 10 apply to all ships for which a Cargo Securing Manual is required. It is recommended that the container securing arrangements in the Cargo Securing Manual are designed in accordance with Sections 3, 5, 6, 8 and 9. Furthermore, it is recommended that the container securing arrangements should be submitted to Lloyd's Register (hereinafter referred to as LR), for formal approval. In cases where LR is authorised to carry out the approval of the Cargo Securing Manual on behalf of a National Administration and the container securing arrangements have not been designed on the basis of the LR Rules nor received formal LR approval, the Cargo Securing Manual will be annotated accordingly highlighting this fact. In general, Cargo Securing Manuals can be approved by LR if authorised by the National Authority.

1.1.2 Where container securing arrangements are fitted, and the design and construction of the system are in accordance with this Chapter, the ship will be eligible to be assigned the special features notation **CCSA** (certified container securing arrangements). In addition to the fixed fittings the Initial and Periodical Survey requirements of Section 10 for all loose fittings are applicable. Where loose container securing fittings are supplied for part container stowage only, the special features notation will be suitably modified.

1.1.3 Where the container securing arrangements have been approved by LR and incorporated into the Cargo Securing Manual, and all proposed loose and fixed cargo securing fittings have been certified by LR or an organisation acceptable to LR, the ship will be eligible to be assigned the descriptive note **CSA** (container securing arrangement) and for an entry to be made in column 6 of the *Register Book*. The Initial and Periodical Survey requirements for loose fittings specified in Section 10 are not applicable.

1.1.4 Fixed fittings being part of the container lashing equipment or which may affect the strength of the ship's hull are subject to approval on the basis of the requirements of this Chapter. Details of the connection and the supporting ship structure require approval to satisfy the design loads determined in accordance with Section 8 or the safe working load of the fixed fitting, as applicable. Drawings are to be submitted showing details of the fittings, the attachment, the local foundations and information about the intended materials and welding.

1.1.5 The requirements for container securing arrangements have been framed in relation to ISO Standard Series 1 ISO 1496-1:1990 including amendment Nos. 1, 2 and 3 Freight Containers. For previous ISO 1496-1:1984 containers reference should be made to the July 2008 LR Rules. Proposals to consider higher allowable forces in accordance with ISO 1496-1 including amendment No.4, 2006 will be specially considered. Proposals for the securing of other types of containers will be specially considered.

1.1.6 Containers are to be loaded so as not to exceed the weights and distribution within the stack according to the cargo securing manual. The permissible loading patterns are to be clearly indicated on the container securing arrangement plan carried on board the ship.

1.1.7 Containers may be approved and certified using LR's *Container Certification Scheme*.

1.1.8 Where it is intended and specified that loose or fixed parts of the container securing system are used for lifting appliance purposes, e.g. pedestal sockets and fittings used for lifting of hatch covers, or twistlocks used for vertical tandem lifting, the requirements of LR's *Code for Lifting Appliances in a Marine Environment* are applicable. If no approval from lifting aspects is sought, the devices will be considered as part of a container securing arrangement only.

1.1.9 The advantage of having an on-board lashing program to calculate forces acting on the stowage arrangement is highlighted. It is recommended that all ships carrying containers on a regular basis are equipped with such a tool. This may be an extension to the loading instrument covered under Ch 4,8.3. It is recommended that the program is approved by LR. If the software to carry out lashing calculations is approved by LR, the ship will be eligible to be assigned the descriptive note **LI (lash)** and for an entry to be made in column 6 of the *Register Book*.

1.1.10 Forward of 0,25L_{pp} aft of the fore perpendicular, it is recommended that all door ends should face aft in order to improve the performance of the container walls to withstand green sea loads.

1.1.11 Improper ship handling related to course and speed or threshold phenomena like parametric rolling can create adverse forces acting on the ship and the cargo which are in excess of the forces determined on the basis of Section 8. It is the responsibility of the master to apply good seamanship in order to mitigate excessive ship motions to reduce forces acting on the cargo stowage arrangements.

1.2 Plans and information required

1.2.1 For all fixed cargo securing arrangements, except container securing arrangements, the following information and plans are to be submitted:

(a) Details of certification including safe working load (SWL), of fixed cargo securing fittings.
(b) Plans of structure in way of fixed cargo securing fittings.
(c) Direction of loads imposed on the ship's fixed cargo securing fittings.
(d) A general arrangement of fixed cargo securing fittings.

1.2.2 For container securing arrangements, the following plans and information are to be submitted:

(a) General arrangement plan showing the disposition and design weights of the containers.
(b) Details of materials, design, scantlings of cell guides structure, lashing bridges, pedestals, and other container securing arrangements, where fitted.
(c) Details of certification, including safe working load (SWL), of fixed and loose container securing fittings.
(d) Plans of structure in way of fixed container securing fittings and arrangements.
(e) Design values of the following ship parameters for the container load departure and arrival conditions:
    Moulded draught (T_c)
    Longitudinal centre of flotation (LCF). If this information is not available, for initial design purposes the longitudinal centre of flotation is to be assumed at ~~0,48~~ 0,45L_{pp} forward of the aft perpendicular.
    Transverse metacentric height (GM)
(f) Design wind speed (V_W).
(g) Where available, details of the long term distribution of ship motions, particularly roll, pitch and heave, in irregular seas which the ship will encounter during its operating life. Where simplified dynamic response data, or other means of assessing the maximum motions of the ship, are proposed they are to be submitted for consideration. In other cases the motions defined in Section 8 will be used.
(h) The lashing calculations in the cargo securing manual are to be based on two design GM values. The lower design value is to be taken as 2,5 per cent of the breadth *B*, and the upper design value is to be taken as 7,5 per cent ~~of~~ *B*. In addition to these two design GM values, actual GM values of the ship in the container loaded condition from the approved trim and stability booklet ~~are to be included when the design GM values are outside the above range~~ may be included, if available.

1.2.3 Where containers of types other than ISO containers are to be incorporated in the stowage arrangement, the cargo securing manual is to indicate clearly the locations where these containers are stowed. The manual is also to indicate the container weights and required securing arrangements for stacks composed entirely of ISO standard containers.

1.3 Securing systems

1.3.1 Containers are to be secured by one, or a combination, of the following systems:

- Corner locking devices.
- Rod, wire or chain lashings.
- Buttresses, shores or equivalent structural restraint.
- Cell guides.

Alternative systems will be considered on the basis of their suitability for the intended purpose.

1.3.2 Dunnage is not to be used in association with approved container securing systems except where forming part of an approved line load stowage, *see* 5.5.

1.4 Symbols and definitions

1.4.1 The following definitions are applicable to this Chapter, except where otherwise stated:

a = breadth of the container, in metres
~~a_0 = acceleration parameter, taken equal to:~~
~~$a_0 = (1,58 - 0,47C_b)\left(\frac{2,4}{\sqrt{L_{pp}}} + \frac{34}{L_{pp}} - \frac{600}{L_{pp}^2}\right)$~~
~~a_{surge} = longitudinal acceleration due to surge, in m/s^2~~
~~$a_{surge} = 0,275a_0\,g$~~
~~a_{sway} = transverse acceleration due to sway, in m/s^2~~
~~$a_{sway} = 0,55a_0\,g$~~
~~a_{heave} = vertical acceleration due to heave, in m/s^2~~
~~$a_{heave} = a_0\,g$~~
~~a_{roll} = roll acceleration at the centre of gravity of the vessel, in rad/s^2~~
~~$a_{roll} = 0,69\frac{\phi}{T_r^2}$~~
~~a_{pitch} = longitudinal acceleration due to pitch, in rad/s^2~~
~~$a_{pitch} = 0,69\left(1 + \frac{0,98}{\sqrt{L_{pp}}}\right)\frac{\psi}{T_p^2}$~~
b = length of the container, in metres
~~C_{p1} = hull whipping factor used in LC_1 to be taken from Fig. 14.1.1~~
e = base of natural logarithms, 2,7183
~~f_{ap} = hull form coefficient and is to be taken as:~~
~~$f_{ap} = 1,2R_A^{0,3}$ for $R_A > 1,0$~~
~~$f_{ap} = 1,2$ for $R_A <= 1,0$~~
~~f_{BK} = coefficient taken equal to:~~
~~$f_{BK} = 1,2$ for ships without bilge keels~~
~~$f_{BK} = 1,0$ for ships with bilge keels~~
~~LC_n = load case n~~
g = acceleration due to gravity and is to be taken as 9,81 m/s^2.
~~x_1~~ x = longitudinal horizontal distance from O_m to the centre of the container ~~(positive forwards)~~, in metres
~~y_1~~ y = transverse horizontal distance from the centreline of the ship to the centre of the container ~~(positive to portside)~~, in metres
~~z_1~~ z_m = vertical distance from O_m to the centre of gravity of the container ~~(positive upwards)~~, in metres
A = side area of the container, in m^2
B = moulded breadth of the ship, in metres
D = moulded depth of the ship, in metres
GM = transverse metacentric height of the ship

KG = vertical distance of the centre of gravity of the ship, above the keel, in metres

L_{pp} = length between perpendiculars of the ship, in metres

O_m = centre of motion, to be taken on the centreline at the longitudinal centre of flotation of the ship and at a distance $2T_c/3 + KG/3$ above the keel, but not less than the greater of T_c and $D/2$

R = the rating, or maximum operating gross weight for which the container is certified, and is equal to the tare weight plus payload of the container, in tonnes

~~R_A = area ratio factor for combined stern and bow shape, defined in Pt 4, Ch 2,2.4~~

T_c = moulded draught in the container load condition, in metres

T_h = full period of heave of the ship, in seconds

T_p = full period of pitch of the ship, in seconds

T_r = full period of roll of the ship, in seconds

V_w = wind speed, in m/s. For ships with an unrestricted worldwide service area notation a wind speed of 40 m/s is to be applied

W = design weight of the container and contents, in tonnes. In general W is to be taken as R unless reduced maximum weights are specified. The following minimum weights W are to be used:

20 ft container	2,5 tonnes
40 ft container	3,5 tonnes
45 ft container	4,0 tonnes
48 ft and 53 ft container	4,5 tonnes

ϕ = maximum single amplitude of roll, in degrees

ψ = maximum single amplitude of pitch, in degrees.

~~*1.4.2* The co-ordinate system used in this Chapter is defined with respect to the right-hand co-ordinate system shown in Fig. 14.1.2, with the origin at the centre of motion.~~

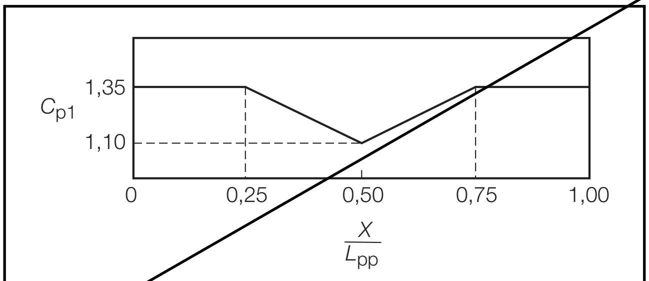


Fig. 14.1.1 The value of C_{p1} along ship length

~~*1.4.3* For ship motions and accelerations defined in this Chapter, the sign convention shown in Fig. 14.1.2 is adopted. The roll, pitch and yaw motions are defined positive clockwise as shown in the figure. For instance, positive sway is defined as the translation toward portside of the vessel and positive pitch as the rotation of the vessel when bow is down and stern is up.~~

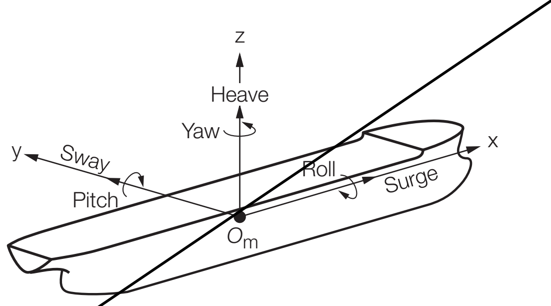


Fig. 14.1.2
Co-ordinate system and sign convention of motions

Section 2
Fixed cargo securing fittings, materials and testing

2.1 General

2.1.1 Randomly selected samples of fixed cargo securing fittings are to be subjected to prototype testing and, upon satisfactory completion, will be granted General Approval.

2.1.2 Randomly selected samples drawn from production runs are to be subjected to production testing prior to delivery to the ship.

2.1.3 Cargo securing fittings, certified by an organization other than LR, will be accepted where the certification scheme is to the satisfaction of LR.

2.2 Materials and design

2.2.1 Steel used for the construction of the fixed cargo securing fittings is to comply with the requirements of the *Rules for the Manufacture, Testing and Certification of Materials* (hereinafter referred to as the Rules for Materials) or with an equivalent specification acceptable to LR. Due account is to be taken of the grade and tensile strength of the hull material in way of the attachment. The chemical composition of the steel is to be such as to ensure acceptable qualities of weldability. Where necessary, tests are to be carried out to establish specific welding procedures.

2.2.2 Where securing arrangements are intended to operate at low ambient temperatures, special consideration is to be given to the specification of the steel.

2.2.3 Proposals for the use of materials other than steel will be specially considered.

2.2.4 Attention is drawn to the need for measures to be taken to prevent water accumulation in pockets or recesses that could lead to excessive corrosion.

2.3 Prototype testing

2.3.1 Prototype tests to determine the breaking or failure loads are to be carried out on at least two randomly selected samples of each item used in the securing system. The relationship between design breaking load and safe working load (SWL) is to be as indicated in Table 14.2.1.

2.3.2 The Surveyor is to be satisfied that the design and materials of the fittings are in accordance with the approved plans.

2.3.3 For acceptance, no permanent deformation (other than due to initial embedding of component parts) is to be induced by test loads up to the proof load given in Table 14.2.1.

2.3.4 When considering the test modes, all expected directions of operation are to be taken into account. Jigs are to be employed, where necessary, in order that satisfactory simulation is obtained.

2.3.5 In the interests of standardisation of the strength of container securing fittings, safe working loads in accordance with Table 14.2.2 are recommended.

2.3.6 Where one of the required two randomly selected test samples required fails before the design breaking load is reached, this can be accepted provided that:

(a) the failure is not less than 95 per cent of the design breaking load;
(b) an additional randomly selected sample is tested satisfactorily; and
(c) the average failure load of the three randomly selected samples is equal to or greater than the design breaking load.

2.4 Production testing

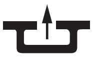
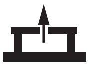
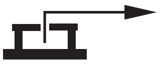
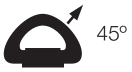
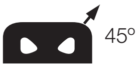
2.4.1 The nature and extent of proposed production testing will be considered by LR, but the arrangements are to be at least equivalent to one of the following testing procedures:
(a) One randomly selected sample from every 50 pieces, or from each batch if less than 50 pieces, is to be proof loaded in accordance with Table 14.2.1.
(b) All fittings are to be loaded to the SWL of the item.

Table 14.2.1 Design breaking loads and proof loads for fixed cargo securing fittings

Minimum design breaking load		Minimum proof load	
SWL ≤ 400 kN	SWL > 400 kN	SWL ≤ 400 kN	SWL > 400 kN
2 x SWL	SWL + 400 kN	1,5 x SWL	SWL + 200 kN

NOTE
Breaking and proof loads for fixed cargo securing fittings of a material other than steel will be specially considered.

Table 14.2.2 Test loads and test modes for fixed container securing fittings

Item No.	Description	Required test modes		Recommended minimum, in kN		
				SWL	Proof load	Breaking load
1	Flush socket		Pull-out load	250	375	500
2	Pedestal socket		Pull-out load	250	375	500
			Tangential load	200	300	400
3	‘D’ ring		Tensile load	250	375	500
4	Lashing plate		Tensile load	250	375	500

NOTES
1. For items 3 and 4, where specially designed for use with chain or steel wire rope (SWR) lashings, a lesser SWL may be considered.
2. For items 1 and 2, where multiple flush sockets or pedestal sockets are involved, test loads are to be applied simultaneously to each socket opening which can be loaded simultaneously in service.
3. For item 4, where multiple lashing points are fitted in one deck plate fitting, testing is to be similarly arranged as for Note 2.
4. Where containers with strength higher than required for ISO containers are used, consideration will be given to the required minimum loads.
5. The test modes illustrated above are diagrammatic only.

2.4.2 Consideration will be given to a reduced frequency of the mechanical production testing proposed in 2.4.1, provided that:

(a) the prototype test results indicate a breaking load at least 50 per cent greater than that required by Table 14.2.1; and
(b) a suitable non-destructive inspection procedure is agreed.

2.4.3 Permanent deformation (other than that due to initial embedding of component parts) will not be accepted unless tests are conducted in accordance with 2.4.1(a) and the SWL of the sample is 250 kN or greater. In this case, consideration may be given to acceptance of permanent deformation in the load range between SWL + 125 kN and the proof load, provided that satisfactory manual operation can be achieved after completion of tests.

2.4.4 In the event of premature failure or serious plastic deformation occurring in a test sample, a further randomly selected sample is to be selected for testing. In the event that this sample is found to be unsatisfactory, the associated batch will be rejected.

■ *Section 3*
Loose container securing fittings, materials and testing

3.1 General

3.1.1 Randomly selected samples of loose container securing fittings are to be subjected to prototype testing and, upon satisfactory completion, will be granted General Approval.

3.1.2 Randomly selected samples drawn from production runs are to be subjected to production testing prior to delivery to the ship in accordance with 3.4.

3.1.3 Loose container securing fittings, certified by an organisation other than LR, will be accepted where the certification scheme is to the satisfaction of LR.

3.1.4 In the following, the term 'Fully automatic fitting' is used to describe fittings which do not require manual operation during unloading of the containers. It should be noted that usually these fittings do not mechanically secure the container in the vertical direction (perpendicular to the hatch cover) in the upright condition when subject to pure vertical motions. Other modes of operation and novel design will be specially considered.

3.2 Materials and design

3.2.1 Steel used for loose container securing fittings is to comply with the requirements of the Rules for Materials or with an equivalent specification acceptable to LR.

3.2.2 Where loose container securing fittings are intended to operate at low ambient temperatures, special consideration is to be given to the specification of the steel.

3.2.3 Proposals for the use of materials other than steel will be specially considered.

3.2.4 Locking devices and other fittings which are inserted into the container castings on the quayside before lifting on board are to be such as to minimise the risk of working loose under the effects of vibration and the risk of falling out.

3.2.5 For twistlocks, bottom twistlocks, midlocks, stackers with intermediate plates and fully automatic fittings the contact areas, for both tension and compression between the fitting and the corner castings of the containers, are to be such as not to exceed a bearing stress of 300 N/mm^2 under the safe working load of the fitting. No increase in the permissible stress level will be given due to higher strength material of the fittings. In case the design is such that the contact area is sloped or inclined and not parallel to the container corner casting, the effective contact area will be specially considered.

3.3 Prototype testing

3.3.1 Prototype tests are to be in accordance with 2.3.1 to 2.3.6, except that Tables 14.3.1 and 14.3.2 are to be applied in lieu of Tables 14.2.1 and 14.2.2 respectively. For vertical lashings, *see* 5.4.7 (b).

3.4 Production testing

3.4.1 The nature and extent of proposed production testing will be considered by LR, but the arrangements are to be at least equivalent to one of the following testing procedures:

(a) For:
    (i) **Loose container securing fittings except chain or wire rope lashings**. One randomly selected sample from every 50 pieces, or from each batch if less than 50 pieces, is to be proof loaded in accordance with Table 14.3.1.
    (ii) **Chain or wire rope lashings**. One randomly selected sample from every 50 pieces or from each batch if less than 50 pieces, is to be tested to breaking.
(b) All fittings, securing devices and lashings are to be proof loaded to the SWL of the item and in addition, one randomly selected sample from every batch of chain or wire rope lashings is to be tested to breaking.

3.4.2 Permanent deformation (other than that due to initial embedding of component parts) will not be accepted unless tests are conducted in accordance with 3.4.1(a)(i) and the SWL of the sample is 250 kN or greater. In this case, consideration may be given to acceptance of permanent deformation in the load range between SWL + 125 kN and the proof load, provided that satisfactory manual operation can be achieved after completion of tests.

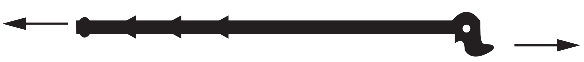
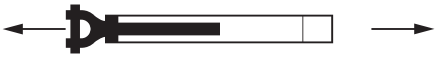
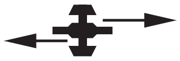
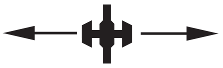
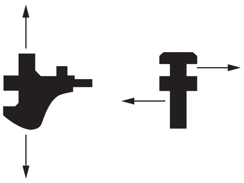
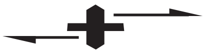
3.4.3 In the event of premature failure or serious plastic deformation occurring in a test sample a further randomly selected sample is to be selected for testing. In the event that this sample is found to be unsatisfactory, the associated batch will be rejected.

Table 14.3.1 Design breaking loads and proof loads for loose container securing fittings

Item	Min. design breaking load		Min. proof load	
	SWL ≤ 400 kN	SWL > 400 kN	SWL ≤ 400 kN	SWL > 400 kN
Lashings				
Wire rope	3 x SWL		1,5 SWL	
Rod: higher tensile steel	2 x SWL			
Chain: mild steel	3 x SWL			
higher tensile steel	2,5 x SWL			
Other loose container securing fittings	2 x SWL	SWL + 400 kN	1,5 x SWL	SWL + 200 kN

NOTES
1. Higher tensile steel is defined for this purpose as steel having a yield stress not less than 315 N/mm^2.
2. Breaking and proof loads for lashings of material other than steel will be considered.

Table 14.3.2 Test loads and test modes for loose container securing fittings

Item No.	Description	Required test modes	Recommended minimum, in kN		
			SWL	Proof load	Breaking load
1	Lashing rod (HTS)		180	270	360
2	Lashing rod		250	375	500
3	Lashing chain (HTS)		80		200
4	Lashing chain (M.S.)		100		300
5	Lashing steel wire rope		120	—	360
6	Turnbuckle	 Tensile load	250	—	500
7	Twistlock (manual, semi-automatic and fully automatic fittings)	 Shear load	200	—	400
		 Tensile load	250	375	500
8	Midlock	 Shear load	200	300	400
		Tensile load	250	375	500
9	Stacker	 Shear load	200	300	400

NOTES
1. Where containers with strength higher than required for ISO containers are used, special consideration will be given to the required minimum loads.
2. The test modes illustrated above are diagrammatic only.
3. Other fittings not covered in this Table may be specially considered, *see also* 3.5.1.

3.5 Function and environmental testing

3.5.1 For fittings of novel design or with special features, in addition to the prototype and production testing, a function test may be required to demonstrate that the fitting is fit for purpose. Details of the function test will be considered on an individual basis taking into consideration the mode of operation of the fitting. In addition, LR reserves the right to require environmental tests. The actual test depends on the individual design of the fitting. The tests are to verify that environmental and ageing effects, such as corrosion, icing, debris contamination, etc., do not impinge on the safe operation of the fitting. In this case LR reserves the right to require the submission of maintenance instructions as part of the approval procedure.

■ *Section 4*

Ship structure

4.1 General

4.1.1 The ship structure and hatch covers in way of fixed cargo securing fittings are to be strengthened as necessary, *see* 1.1.7.

4.1.2 The fitting of a breakwater may be required, *see* 8.1.9.

4.2 Strength

4.2.1 The SWL of the fixed cargo securing fitting is to be used as the design load when approving the weld attachments and the support structure of the fixed cargo securing fitting.

4.2.2 For container securing arrangements, the design load when approving the weld attachment and supporting structure is to be calculated in accordance with Section 9.

4.2.3 When considering the loads, all expected directions of operation are to be taken into account.

4.2.4 Stresses induced in the weld attachments, supporting structure, cell guides, lashing bridges and other structures serving as fixed cargo securing points, determined using the design loads as defined in 4.2.1 to 4.2.3, are not to exceed the permissible values given in Table 14.4.1.

Table 14.4.1 Permissible stress values

	Permissible stress, N/mm^2
Normal stress (bending, tension, compression)	$0,67\sigma_o$
Shear stress	$0,4\sigma_o$
Combined stress	$0,86\sigma_o$
Symbols	
σ_o = specified minimum yield stress, in N/mm^2	

■ *Section 5*

Container securing arrangements for stowage on exposed decks without cell guides

5.1 General

5.1.1 Containers stowed on deck or on hatch covers are generally to be aligned in the fore and aft direction, but alternative arrangements will be considered.

5.1.2 Containers are to be stowed so that they do not extend beyond the ship's side. Adequate support is to be provided where they overhang hatch coamings or other deck structures. The stowage arrangements are to be such as to permit safe access for personnel in the necessary working of the ship, and to provide sufficient access for operation and inspection of the securing devices.

5.1.3 Where containers are stowed on hatch covers, the covers are to be effectively restrained against sliding by approved type stoppers or equivalent. Details of the locations of stoppers relative to the supporting structure are to be submitted at an early stage.

5.1.4 Stanchions and similar structure supporting containers and securing devices such as D-rings for lashings, are to be of adequate strength for the imposed loads and of sufficient stiffness to minimise any deflection which could lead to a reduction in the effectiveness of the securing device.

5.1.5 In the region forward of $0,25L_{pp}$ abaft the fore perpendicular additional securing devices may be required, *see* 8.1.10.

5.1.6 In general, stowage of heavy containers on top of lighter containers is to be avoided, unless validated as being satisfactory by an approved on-board lashing program or covered by the approved container securing arrangement.

5.1.7 Regarding the use of fully automatic fittings the following requirements apply:

(a) For fittings where the locking method requires defined clearances between the corner castings and the fixed foundations, such fittings are not to be used at the lowest tier of a stack which is resting with one side on a hatch cover panel and bridging to a container stanchion. The same applies if the stack is resting on different hatch cover panels or foundations where relative deflection during ship operation can occur.

(b) If the lashing system consists of a combination of fully automatic fittings with lashing rods, only internal cross lashings are to be used. No external lashings or vertical lashings are to be applied, unless the clearance of the loose securing fitting under safe working loads is insignificantly small. Alternative arrangements will be specially considered taking into consideration the clearances of the fittings.

5.2 Containers in one tier

5.2.1 Containers are to be secured at their lower corners by approved locking devices.

5.2.2 Alternatively, containers may be secured by lashings fitted diagonally or vertically at both ends of each container, in association with cone fittings at each container corner.

5.3 Containers in two tiers

5.3.1 Containers are to be secured at their lower corners at each tier by approved locking devices.

5.3.2 Where the calculations indicate that separation forces will not occur at any point in the stack, double stacking cones may be fitted at all internal corners of the stack and bridge fittings used to connect the tops of the rows in the transverse direction. Locking devices are to be fitted at all external corners.

5.3.3 Alternatively, containers may be secured by lashings in association with stacking cones or, where the calculations indicate that separation forces may occur, with locking devices.

5.4 Containers in more than two tiers

5.4.1 Containers are to be secured at their lower corners at each tier by approved locking devices.

5.4.2 Alternatively, containers may be secured by lashings. One or two tiers of lashings may be fitted in association with stacking cones or, where the calculations indicate that separation forces may occur, with locking devices.

5.4.3 When lashings are employed, they are to be fitted to the bottom corner casting of the upper container and not to the top casting of the container below.

5.4.4 Proposals to use lashings in pairs (para-lash arrangements) will be considered. Lashings in pairs are to be attached one to the bottom corner fitting of the upper tier and the other to the top corner fitting of the lower tier container. Suitable connections are to be provided at the lower ends. The effectiveness of paired lashings is to be taken as equal to 1,5 times that of a single lashing.

5.4.5 Where tiers are fitted at higher levels, they are to be secured by locking devices at each corner and each tier.

5.4.6 Proposals to use horizontal lashings connected to lashing bridges will be specially considered. The forces in such securing systems are to be determined by direct calculations taking into account the following effects:

- stiffness of the container walls, the lashings and the lashing bridge; and
- the possible horizontal displacements of the containers relative to the lashing bridge due to the clearances of the hatch cover stoppers and the container securing fittings.

5.4.7 When vertical lashings are used in combination with container securing fittings, consideration is to be given to the vertical clearances between the fittings and the container corner castings.

(a) The lashing assembly is to remain elastic when subject to an elongation equating to the number of interface fittings fitted below the point where the vertical lashing is applied to the stack. In order to avoid overstressing of the rod and the turnbuckle, provision of spring or elastic elements incorporated into the turnbuckle may be advantageous. When lashing from lashing bridge level, the number of interfaces is to be counted down to the level where the lowest container is resting. The lashing rod is to be fitted to the bottom casting of the container. For container securing fittings having design clearances in accordance with ISO 3874, a nominal clearance per fitting of 10 mm is to be taken to determine the total elongation of the lashing system. For fittings having clearances in excess of 10 mm, the total elongation is to be calculated taking into consideration the higher clearances.

(b) A prototype test is to be carried out to demonstrate that the vertical lashing has a safe working load of 150 kN when elongated up to the calculated total design clearance plus 10 per cent without plastic deformation.

(c) To take into account the load bearing effect of the vertical lashing arrangement when performing lashing calculations, the permissible calculated lifting force can be increased by 150 kN in addition to the safe working load of the container securing fitting. The nominal lifting force is not to exceed 400 kN at the securing fittings below the fitting position of the vertical lashing.

5.4.8 For stowage arrangements incorporating fully automatic fittings which do not mechanically secure the container in pure vertical direction when subject to vertical motions, it is to be ensured that no separation occurs under the load cases specified in 8.2.3. In addition, where exposed stacks are secured with fully automatic fittings without internal cross lashings, provision is to be made to prevent buoyancy forces acting on the container which could disengage the containers. In this case the use of effective side screens is required. Otherwise, the first tier of containers is to be secured by manual or semi-automatic twistlocks.

5.4.9 If the carriage of one or more tiers of 20 ft containers being overstowed with at least one tier of 40 ft containers, so called ‘Russian Stow Arrangement’ is desired, the following requirements apply.

(a) At the 20 ft gap the containers are to be secured by means of midlocks, whereas the fore and aft ends are to be secured by twistlocks and if necessary supplemented by lashing rods.

(b) The 40 ft overstow container is to be secured by twistlocks or if necessary with a combination of twistlocks and lashing rods. The stack is to be assessed in a two step procedure as follows:

  (i) For location at the 40 ft ends the entire mixed stack is to be considered as a 40 ft stack. The weights of the 40 ft containers are to be considered in the calculations. For the tiers of 20 ft containers, the weight of one 20 ft container is to be taken as the basis for the calculation at each tier.

(ii) For the location of the 20 ft tiers at the mid bay position the assessment is to be carried out as for an unlashed stack. The 40 ft overstow container does not need to be taken into consideration.

5.5 Line Load stowage

5.5.1 Where the containers are supported on bearers placed to distribute the stackweight as Line Loads, the following requirements are to be complied with:

(a) The stack is, in general, to comprise a maximum of two tiers of loaded containers.
(b) The load from the upper tier is to be transferred through the container corners. Line loading is not to be used between tiers.
(c) The load on each vertical corner post of the bottom tier, calculated in accordance with Section 9, is not to exceed one half the Rated Load of the container.
(d) Where the calculations indicate that lifting forces may occur, locking devices are to be fitted at the container corners.
(e) The clearance below the bottom container corner casting is to be such that the stacking cone or equivalent cannot be dislodged under shear loading.

5.5.2 Where an approved Line Load stowage system is installed the special features notation will be suitably modified.

5.6 Systems incorporating structural restraint

5.6.1 Containers may be secured by the use of a fixed structure providing permanent buttresses in association with portable frameworks. Proposals to adopt such systems will be considered on the basis of the loads developed in the structure and the corresponding stresses.

5.6.2 The framework or other devices securing the containers are to be aligned with the container corner fittings and any clearance gap is to be kept to the minimum to reduce shifting.

■ *Section 6*

Container securing arrangements for underdeck stowage without cell guides

6.1 General

6.1.1 Containers are generally to be stowed in holds in the fore and aft direction, but alternative arrangements will be considered. The securing arrangements are to be designed on the basis of the most severe distribution of loads which may arise in the container stack.

6.1.2 Containers may be secured by locking devices only or by a combination of locking devices, buttresses, shores or lashings. Containers are, in general, to be restrained at every corner at the base of the stack and at all intermediate levels.

6.1.3 Where stacks consist of one or two tiers only, consideration will be given to the omission of corner locking devices. Containers must, however, be secured by a minimum of two corner locking devices.

6.1.4 Where the calculations indicate that separation forces could occur at any particular level, twistlocks or equivalent means of securing are to be fitted at that level. Elsewhere, consideration will be given to the use of double stacking cones.

6.1.5 Where the calculations indicate that separation forces will not occur between containers at any level, consideration will be given to the use of stacking cones in lieu of locking devices throughout.

6.1.6 Buttresses are generally to be of the tension and compression type and are to be provided with means of adjustment to ensure tightness when fitted in place. Where applicable, the attachment to the ship's structure is also to include means for vertical adjustment of the buttress to match container stacks of different heights.

6.1.7 Shores of the compression only type may be permanently attached to the ship structure or they may be hinged or portable. When in place they are to abut the container corner fittings with minimal clearance. Means are to be provided to prevent slackening of the device.

6.1.8 Adjacent stacks of containers are to be linked in line with buttresses or shores in order to transmit lateral loads. The fittings used for these linkages are to be of adequate strength to transmit the loads imposed.

6.1.9 The ship's structure supporting shores and buttresses is to be reinforced as necessary.

6.1.10 Proposals for alternative securing systems, including systems relying on minimal clearance between containers and hull structure, will be specially considered.

6.1.11 Attention is drawn to the safety at work aspects for fittings which require operation on top of containers, e.g. double stacking cones, bridge fittings, buttresses and shores. Where these fittings are used, fall protection is to be provided.

■ *Section 7*

Container securing arrangements for stowage using cell guides

7.1 General

7.1.1 Cell guide systems may be fitted to support containers stowed in holds or on exposed decks.

7.1.2 The cell guides are not to form an integral part of the ship's structure. The guide system is generally to be so designed as to keep it free of the main hull stresses.

7.1.3 Cell guides are to be designed to resist loads caused by loading and unloading of the containers, to prevent shifting of the containers and to transmit the loads caused by motions of the ship into the main hull structure.

7.2 Arrangement and construction

7.2.1 Cell guides are to be of robust construction and generally fabricated from steel plate and rolled sections. They are to have sufficient vertical extent and continuity to provide efficient support to containers. Guide bars are to be effectively attached to the supporting structure to prevent tripping or distortion resulting from container loading.

7.2.2 The intersection between cell guide and cross-ties is to provide adequate torsional stability.

7.2.3 Intermediate brackets are to be fitted to vertical cell guides at suitable intervals.

7.2.4 The cell guides are to give a total clearance between the container and guide bars not exceeding 25 mm in the transverse direction and 40 mm in the longitudinal direction. The deviation of the cell guide bar from its intended line is not generally to exceed 4 mm in the transverse direction and 5 mm in the longitudinal direction.

7.2.5 Athwartship cross-ties are to be fitted between cell guides at a spacing determined from the loading on the guides but, generally, not more than 3,0 m apart. Wherever possible, cross-ties are to be arranged in line with the corners of the containers as stowed and are to be supported against fore and aft movement at a minimum of two points across the breadth of the hold. Where, however, the maximum fore and aft deflection in the cross-tie can be shown not to exceed 20 mm, then one support point may be accepted.

7.2.6 Longitudinal tie bars may be required to be fitted where shown necessary by the force calculations for the structure. Where fitted they are to comply with the requirements of 7.2.5.

7.2.7 Where, at the sides or ends of holds, the guide rails are fitted to transverse or longitudinal bulkheads, the bulkhead is to be locally reinforced to resist the additional loads.

7.2.8 If the carriage of 45 ft Euro containers complying with EU Directive 96/53 is specified to be carried in 45 ft cell guides, attention is to be paid with regard to the arrangement of the corner castings, *see* Fig. 14.7.1. The guide bars need to be increased in order to ensure that a minimum design overlap a of 20 mm is achieved taking into account the design clearances and tolerances defined in 7.2.4. Consideration is to be given to the torsional loads being applied to the guide bars.

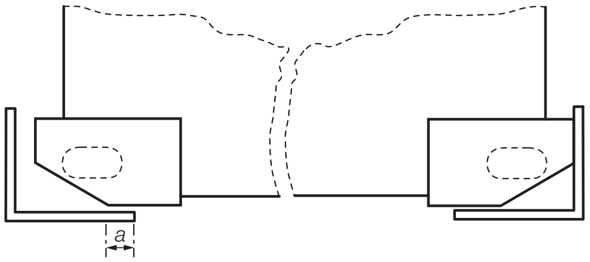


Fig. 14.7.1 45 ft euro container in cell guides

7.3 Carriage of 20 ft containers in 40 ft cell guides in holds

7.3.1 Where the cell guides are arranged for the carriage of 40 ft containers, provision may be made for the installation of temporary intermediate cell guides for 20 ft containers. The permanent structure is to be designed such that it is suitable for either loading pattern.

7.3.2 Alternatively, permanent means for the support of 20 ft containers at the mid-length of a cell arranged for 40 ft containers will be considered. Such means may include the following:

(a) A pillar (inboard) and vertical rest bar (on the longitudinal bulkhead) against which the container stack may rest. The pillar is to be supported laterally by the deck structure over and is to be sufficiently stiff to control lateral deflection of the container stacks.

(b) Guide bars supported transversely by slim structure within the gap between containers and with longitudinal ties as necessary.

Details of proposals will be individually considered, taking into account the loads on the support structure and the resulting deflections.

7.3.3 Where it is desired to stow 20 ft containers without external support at the mid-bay location with or without 40 ft overstow, so called ‘mixed stowage’, arrangements meeting the following requirements are applicable:

(a) Maximum homogeneous container weights for 20 ft containers stowed in cell guides with no 40 ft container overstowed, can be derived from Tables 14.7.1 and 14.7.2 depending on the transverse acceleration and the number of tiers in the stack.

(b) Maximum homogeneous container weights for 20 ft containers stowed in cell guides with at least one 40 ft container overstowed, can be derived from Table 14.7.3 depending on the transverse acceleration and the number of tiers in the stack.

(c) Tables 14.7.1 to 14.7.3 have been derived on the basis of all containers in a stack having the same homogeneous weight. Where it is intended to carry non-homogeneous mixed stowage stacks, heavier containers than the table values stated in Tables 14.7.1 to 14.7.3 can be loaded in the lower tiers provided that the total stack weight derived from the tables will not be exceeded. Furthermore, no container having a weight in excess of the maximum weight stated in the tables is to be stowed on top of a lighter container. However, the total accumulated stack weight derived from the above-mentioned tables may be increased by loading the lowest container in the stack up to its maximum rated weight.

(d) Means are to be provided to prevent transverse sliding of the bottom of the stacks of 20 ft containers at the mid bay position. This is to be in the form of permanently attached chocks at the inner bottom or equivalent. The design clearance is to be the same as for the cell guides and in accordance with 7.2.4.

(e) Stacking cones are to be fitted at each corner between tiers of the 20 ft containers to prevent transverse and longitudinal sliding. In addition, where a 40 ft container is required to be stowed above 20 ft containers, stacking cones are to be fitted at the ends of the 40 ft container between the 40 ft container and the 20 ft containers below.

(f) The 20 ft containers are to have closed steel walls and top (no open frame containers, e.g. tank or bulk containers).
(g) The orientation of the containers is to be such that all front ends or door ends are facing in one direction.
(h) Cones are to be fitted on the inner bottom in way of the cell guides to restrain container movement in the longitudinal direction.
(j) The containers are to be stowed in the hold in block stowage. In general, free standing stacks due to adjacent empty stacks are to be avoided.

Proposals for stowage arrangements other than the above will be individually considered and are to be accompanied by supporting calculations.

7.4 Cell guide systems on exposed decks

7.4.1 Analysis methods for the strength of the cell guide structure are to take due account of the interactive effects between guide structure and supporting deck structure and also of the deformation of the hull girder.

7.4.2 At its lower end the guide structure is to be efficiently connected to the deck structure. Cross-ties are to be arranged between guides in a transverse direction at a spacing determined by the loading on the guides but in general not more than 3 m apart. Cross-bracing members of adequate strength and sufficient number are to be fitted in the transverse and longitudinal directions to prevent excessive deflection of the guide structure.

7.4.3 The height of guide bars above the deck is to be sufficient to ensure adequate restraint to the uppermost container tiers.

7.4.4 Where the cell guide structure is attached to highly stressed hull or deck elements, such as sheerstrake, special attention is to be given to the design of the connection and the grade and quality of steel utilised.

7.5 Entry guide devices

7.5.1 A device to pre-centre the container and direct it into the cell guides is normally to be fitted at the top of the guide bars. Such devices include:
- fixed even peaks;
- fixed high and low peaks;
- ‘flip-flop’ systems;

but other devices will be considered. The device is to be of robust construction.

Table 14.7.1 Maximum container weights of ISO 1496-1:1990 20 ft containers stowed in 40 ft cell guides with no overstow; Container's Rated Weight = 24 t

Lowest tier Transverse acceleration (g)	Maximum homogeneous container weights, in tonnes									
	3 Tiers	4 Tiers	5 Tiers	6 Tiers	7 Tiers	8 Tiers	9 Tiers	10 Tiers	11 Tiers	12 Tiers
0,350	24,0	24,0	24,0	20,2	17,3	14,8	13,4	11,6	10,6	9,5
0,355	24,0	24,0	24,0	20,0	17,1	14,6	13,3	11,6	10,5	9,4
0,360	24,0	24,0	24,0	19,7	16,9	14,5	13,2	11,5	10,5	9,3
0,365	24,0	24,0	24,0	19,5	16,7	14,3	13,1	11,4	10,4	9,3
0,370	24,0	24,0	23,9	19,3	16,5	14,1	13,0	11,3	10,3	9,2
0,375	24,0	24,0	23,6	19,0	16,3	14,0	12,9	11,3	10,2	9,2
0,380	24,0	24,0	23,3	18,8	16,1	13,8	12,7	11,2	10,2	9,1
0,385	24,0	24,0	23,0	18,6	15,9	13,6	12,6	11,1	10,1	9,0
0,390	24,0	24,0	22,7	18,4	15,8	13,5	12,5	11,0	10,0	9,0
0,395	24,0	24,0	22,5	18,2	15,6	13,3	12,4	10,9	9,9	8,9
0,400	24,0	24,0	22,2	18,0	15,4	13,2	12,3	10,8	9,9	8,9
0,405	24,0	24,0	22,0	17,8	15,3	13,1	12,1	10,7	9,8	8,8
0,410	24,0	24,0	21,8	17,6	15,1	13,0	12,0	10,7	9,7	8,8
0,415	24,0	24,0	21,5	17,5	15,0	12,9	11,8	10,6	9,7	8,7
0,420	24,0	24,0	21,3	17,3	14,8	12,7	11,7	10,4	9,6	8,7
0,425	24,0	24,0	21,1	17,2	14,7	12,6	11,5	10,3	9,5	8,6
0,430	24,0	24,0	20,9	17,0	14,6	12,5	11,4	10,2	9,4	8,6
0,435	24,0	24,0	20,7	16,9	14,5	12,4	11,3	10,1	9,4	8,5
0,440	24,0	24,0	20,6	16,8	14,4	12,4	11,1	10,0	9,3	8,5
0,445	24,0	23,9	20,4	16,6	14,3	12,3	11,0	9,9	9,2	8,4
0,450	24,0	23,7	20,2	16,5	14,1	12,2	10,9	9,9	9,2	8,3
0,455	24,0	23,6	20,0	16,4	14,0	12,1	10,8	9,8	9,1	8,3
0,460	24,0	23,4	19,9	16,2	13,9	12,0	10,7	9,7	9,0	8,2
0,465	24,0	23,3	19,7	16,1	13,8	11,9	10,6	9,6	8,9	8,1
0,470	24,0	23,1	19,6	16,0	13,7	11,8	10,6	9,5	8,9	8,1
0,475	24,0	23,0	19,5	15,9	13,6	11,7	10,5	9,4	8,8	8,0
0,480	24,0	22,9	19,3	15,8	13,5	11,6	10,5	9,4	8,7	7,9
0,485	24,0	22,7	19,2	15,7	13,4	11,5	10,4	9,3	8,6	7,9
0,490	24,0	22,6	19,1	15,6	13,3	11,4	10,3	9,2	8,5	7,8
0,495	24,0	22,5	18,9	15,5	13,2	11,3	10,3	9,1	8,5	7,7
0,500	24,0	22,4	18,8	15,4	13,1	11,2	10,2	9,1	8,4	7,7
0,505	24,0	22,3	18,7	15,3	13,0	11,2	10,1	9,0	8,3	7,6
0,510	24,0	22,1	18,6	15,2	13,0	11,1	10,1	8,9	8,3	7,6
0,515	24,0	22,0	18,4	15,1	12,9	11,0	10,0	8,9	8,2	7,5
0,520	24,0	21,9	18,3	15,0	12,8	10,9	9,9	8,8	8,1	7,4
0,525	24,0	21,8	18,2	14,9	12,7	10,9	9,9	8,7	8,1	7,4
0,530	24,0	21,7	18,1	14,8	12,6	10,8	9,8	8,7	8,0	7,3
0,535	24,0	21,6	18,0	14,7	12,5	10,7	9,7	8,6	8,0	7,3
0,540	24,0	21,5	17,9	14,6	12,4	10,6	9,6	8,5	7,9	7,2
0,545	24,0	21,4	17,7	14,5	12,3	10,6	9,6	8,5	7,8	7,1
0,550	24,0	21,3	17,6	14,4	12,3	10,5	9,5	8,4	7,8	7,1
0,555	24,0	21,2	17,5	14,3	12,2	10,4	9,4	8,4	7,7	7,0
0,560	24,0	21,1	17,4	14,2	12,1	10,4	9,3	8,3	7,7	7,0
0,565	24,0	21,0	17,3	14,2	12,0	10,3	9,3	8,3	7,6	6,9
0,570	24,0	20,9	17,2	14,1	11,9	10,2	9,2	8,2	7,6	6,9
0,575	24,0	20,8	17,1	14,0	11,9	10,2	9,1	8,2	7,5	6,8
0,580	24,0	20,7	17,0	13,9	11,8	10,1	9,0	8,1	7,5	6,8
0,585	24,0	20,6	16,9	13,8	11,7	10,1	9,0	8,1	7,4	6,8
0,590	24,0	20,5	16,8	13,7	11,6	10,0	8,9	8,0	7,4	6,7
0,595	24,0	20,4	16,7	13,7	11,6	9,9	8,8	8,0	7,3	6,7
0,600	24,0	20,4	16,6	13,6	11,5	9,9	8,8	7,9	7,3	6,6
0,605	24,0	20,3	16,5	13,5	11,4	9,8	8,7	7,9	7,2	6,6
0,610	24,0	20,2	16,5	13,4	11,4	9,8	8,7	7,8	7,2	6,5
0,615	24,0	20,1	16,4	13,4	11,3	9,7	8,6	7,8	7,1	6,5
0,620	24,0	20,0	16,3	13,3	11,2	9,7	8,6	7,7	7,1	6,5
0,625	24,0	20,0	16,2	13,2	11,2	9,6	8,6	7,7	7,0	6,4
0,630	24,0	19,9	16,1	13,1	11,1	9,6	8,5	7,6	7,0	6,4
0,635	24,0	19,8	16,0	13,1	11,1	9,5	8,5	7,6	6,9	6,3
0,640	24,0	19,7	15,9	13,0	11,0	9,5	8,4	7,5	6,9	6,3
0,645	24,0	19,7	15,9	12,9	10,9	9,4	8,4	7,5	6,9	6,3
0,650	24,0	19,6	15,8	12,9	10,9	9,4	8,4	7,5	6,8	6,2

Table 14.7.2 **Maximum container weights of ISO 1496-1:1990 20 ft containers stowed in 40 ft cell guides with no overstow; Container's Rated Weight = 30,5 t**

Lowest tier Transverse acceleration (g)	Maximum homogeneous container weights, in tonnes									
	3 Tiers	4 Tiers	5 Tiers	6 Tiers	7 Tiers	8 Tiers	9 Tiers	10 Tiers	11 Tiers	12 Tiers
0,350	30,5	28,1	25,0	20,2	17,3	14,8	13,4	11,6	10,6	9,5
0,355	30,5	27,8	24,7	20,0	17,1	14,6	13,3	11,6	10,5	9,4
0,360	30,5	27,6	24,4	19,7	16,9	14,5	13,2	11,5	10,5	9,3
0,365	30,5	27,3	24,1	19,5	16,7	14,3	13,1	11,4	10,4	9,3
0,370	30,5	27,0	23,9	19,3	16,5	14,1	13,0	11,3	10,3	9,2
0,375	30,5	26,7	23,6	19,0	16,3	14,0	12,9	11,3	10,2	9,2
0,380	30,5	26,4	23,3	18,8	16,1	13,8	12,7	11,2	10,2	9,1
0,385	30,5	26,2	23,0	18,6	15,9	13,6	12,6	11,1	10,1	9,0
0,390	30,5	25,9	22,7	18,4	15,8	13,5	12,5	11,0	10,0	9,0
0,395	30,5	25,7	22,5	18,2	15,6	13,3	12,4	10,9	9,9	8,9
0,400	30,5	25,4	22,2	18,0	15,4	13,2	12,3	10,8	9,9	8,9
0,405	30,5	25,2	22,0	17,8	15,3	13,1	12,1	10,7	9,8	8,8
0,410	30,5	25,0	21,8	17,6	15,1	13,0	12,0	10,7	9,7	8,8
0,415	30,5	24,8	21,5	17,5	15,0	12,9	11,8	10,6	9,7	8,7
0,420	30,5	24,7	21,3	17,3	14,8	12,7	11,7	10,4	9,6	8,7
0,425	30,5	24,5	21,1	17,2	14,7	12,6	11,5	10,3	9,5	8,6
0,430	30,5	24,3	20,9	17,0	14,6	12,5	11,4	10,2	9,4	8,6
0,435	30,5	24,2	20,7	16,9	14,5	12,4	11,3	10,1	9,4	8,5
0,440	30,5	24,0	20,6	16,8	14,4	12,4	11,1	10,0	9,3	8,5
0,445	30,5	23,9	20,4	16,6	14,3	12,3	11,0	9,9	9,2	8,4
0,450	30,5	23,7	20,2	16,5	14,1	12,2	10,9	9,9	9,2	8,3
0,455	30,5	23,6	20,0	16,4	14,0	12,1	10,8	9,8	9,1	8,3
0,460	30,5	23,4	19,9	16,2	13,9	12,0	10,7	9,7	9,0	8,2
0,465	30,5	23,3	19,7	16,1	13,8	11,9	10,6	9,6	8,9	8,1
0,470	30,5	23,1	19,6	16,0	13,7	11,8	10,6	9,5	8,9	8,1
0,475	30,5	23,0	19,5	15,9	13,6	11,7	10,5	9,4	8,8	8,0
0,480	30,5	22,9	19,3	15,8	13,5	11,6	10,5	9,4	8,7	7,9
0,485	30,5	22,7	19,2	15,7	13,4	11,5	10,4	9,3	8,6	7,9
0,490	30,5	22,6	19,1	15,6	13,3	11,4	10,3	9,2	8,5	7,8
0,495	30,5	22,5	18,9	15,5	13,2	11,3	10,3	9,1	8,5	7,7
0,500	30,5	22,4	18,8	15,4	13,1	11,2	10,2	9,1	8,4	7,7
0,505	30,5	22,3	18,7	15,3	13,0	11,2	10,1	9,0	8,3	7,6
0,510	30,4	22,1	18,6	15,2	13,0	11,1	10,1	8,9	8,3	7,6
0,515	30,4	22,0	18,4	15,1	12,9	11,0	10,0	8,9	8,2	7,5
0,520	30,4	21,9	18,3	15,0	12,8	10,9	9,9	8,8	8,1	7,4
0,525	30,4	21,8	18,2	14,9	12,7	10,9	9,9	8,7	8,1	7,4
0,530	30,4	21,7	18,1	14,8	12,6	10,8	9,8	8,7	8,0	7,3
0,535	30,3	21,6	18,0	14,7	12,5	10,7	9,7	8,6	8,0	7,3
0,540	30,3	21,5	17,9	14,6	12,4	10,6	9,6	8,5	7,9	7,2
0,545	30,2	21,4	17,7	14,5	12,3	10,6	9,6	8,5	7,8	7,1
0,550	30,1	21,3	17,6	14,4	12,3	10,5	9,5	8,4	7,8	7,1
0,555	29,9	21,2	17,5	14,3	12,2	10,4	9,4	8,4	7,7	7,0
0,560	29,8	21,1	17,4	14,2	12,1	10,4	9,3	8,3	7,7	7,0
0,565	29,6	21,0	17,3	14,2	12,0	10,3	9,3	8,3	7,6	6,9
0,570	29,4	20,9	17,2	14,1	11,9	10,2	9,2	8,2	7,6	6,9
0,575	29,1	20,8	17,1	14,0	11,9	10,2	9,1	8,2	7,5	6,8
0,580	28,9	20,7	17,0	13,9	11,8	10,1	9,0	8,1	7,5	6,8
0,585	28,7	20,6	16,9	13,8	11,7	10,1	9,0	8,1	7,4	6,8
0,590	28,5	20,5	16,8	13,7	11,6	10,0	8,9	8,0	7,4	6,7
0,595	28,3	20,4	16,7	13,7	11,6	9,9	8,8	8,0	7,3	6,7
0,600	28,2	20,4	16,6	13,6	11,5	9,9	8,8	7,9	7,3	6,6
0,605	28,1	20,3	16,5	13,5	11,4	9,8	8,7	7,9	7,2	6,6
0,610	28,0	20,2	16,5	13,4	11,4	9,8	8,7	7,8	7,2	6,5
0,615	28,0	20,1	16,4	13,4	11,3	9,7	8,6	7,8	7,1	6,5
0,620	28,0	20,0	16,3	13,3	11,2	9,7	8,6	7,7	7,1	6,5
0,625	27,9	20,0	16,2	13,2	11,2	9,6	8,6	7,7	7,0	6,4
0,630	27,9	19,9	16,1	13,1	11,1	9,6	8,5	7,6	7,0	6,4
0,635	27,9	19,8	16,0	13,1	11,1	9,5	8,5	7,6	6,9	6,3
0,640	27,9	19,7	15,9	13,0	11,0	9,5	8,4	7,5	6,9	6,3
0,645	27,9	19,7	15,9	12,9	10,9	9,4	8,4	7,5	6,9	6,3
0,650	27,9	19,6	15,8	12,9	10,9	9,4	8,4	7,5	6,8	6,2

Table 14.7.3 Maximum container weights of ISO 1496-1:1990 20 ft containers stowed in 40 ft cell guides with overstow

Lowest tier Transverse acceleration (g)	Maximum container weights, in tonnes, *see* Note					
	3 Tiers	4 Tiers	5 Tiers	6 Tiers	7 Tiers	8 Tiers
0,4	24,0	24,0	24,0	19,6	17,1	15,2
0,405	24,0	24,0	23,6	19,4	17,0	15,1
0,41	24,0	24,0	23,3	19,2	16,8	14,9
0,415	24,0	24,0	22,9	19,1	16,7	14,8
0,42	24,0	24,0	22,5	18,9	16,5	14,7
0,425	24,0	24,0	22,1	18,8	16,4	14,5
0,43	24,0	24,0	21,8	18,6	16,2	14,4
0,435	24,0	24,0	21,5	18,4	16,1	14,3
0,44	24,0	24,0	21,2	18,3	15,9	14,1
0,445	24,0	24,0	21,0	18,1	15,8	14,0
0,45	24,0	24,0	20,8	18,0	15,7	13,9
0,455	24,0	24,0	20,6	17,8	15,5	13,7
0,46	24,0	24,0	20,5	17,7	15,4	13,6
0,465	24,0	24,0	20,3	17,5	15,2	13,5
0,47	24,0	24,0	20,2	17,3	15,1	13,3
0,475	24,0	24,0	20,1	17,2	14,9	13,2
0,48	24,0	23,9	19,9	17,0	14,8	13,1
0,485	24,0	23,8	19,8	16,9	14,6	12,9
0,49	24,0	23,6	19,6	16,7	14,5	12,8
0,495	24,0	23,4	19,4	16,5	14,3	12,7
0,5	24,0	23,2	19,3	16,4	14,2	12,5
0,505	24,0	23,1	19,1	16,2	14,1	12,4
0,51	24,0	22,9	18,9	16,1	13,9	12,2
0,515	24,0	22,7	18,8	15,9	13,8	12,1
0,52	24,0	22,5	18,6	15,7	13,6	12,0
0,525	24,0	22,4	18,5	15,6	13,5	11,8
0,53	24,0	22,3	18,3	15,4	13,3	11,7
0,535	24,0	22,2	18,2	15,3	13,2	11,6
0,54	24,0	22,1	18,1	15,1	13,0	11,4
0,545	24,0	22,0	18,0	15,0	12,9	11,3
0,55	24,0	21,8	17,9	14,8	12,8	11,2

NOTE
40 ft overstow containers not included in the number of tiers.

■ *Section 8*
Determination of forces for container securing arrangements

8.1 General

8.1.1 The forces acting in the securing system are to be determined for each loading condition and associated set of motions of the ship. Although the operation of anti-roll devices or other systems may improve the behavior of the ship in seaways, the effect of such devices should not be taken into account to reduce the determination of the forces for container securing arrangements.

8.1.2 The following forces are to be taken into account:

- Static gravity forces.
- Inertial forces generated by accelerations due to roll, pitch~~,~~ and heave~~, surge and sway~~ motions of the ship.
- Wind forces.
- Forces imposed by the securing arrangements.
- Wave impact forces.
- ~~Additional forces due to hull form at the forward and aft ends and due to hull whipping.~~

~~*8.1.3* Ship response data given in 1.4 will be used for the calculation of accelerations.~~

8.1.3 Where ship response data is not available the values for roll, pitch and heave as given in Table 14.8.1 will be used for the calculation.

8.1.4 Wind forces are generally to be based on a maximum wind speed of 40 m/s. Only positive forces of wind pressure need to be applied. That means no suction forces need to be taken into consideration.

~~**Table 14.8.1 Ship motions**~~

Motion	Maximum single amplitude (degrees)	Periods (seconds)
Roll	$\phi = \dfrac{3979\,(1{,}25 - 0{,}025T_r)\,f_{BK}}{(B + 75)}$ ϕ is not to be taken less than 22° but need not exceed 30°	$T_r = \dfrac{0{,}84B}{\sqrt{GM}}$
Pitch	$\psi = 1350L_{pp}^{-0{,}94}\left(1{,}0 + \left(\dfrac{0{,}82}{\sqrt{L_{pp}}}\right)^{1{,}2}\right)$ ψ = need not exceed 8°	$T_p = 0{,}80\sqrt{C_1L_{pp}}$ where C_1 is generally to be taken as 0,52 For the head sea condition, C_1 should be taken as 0,95

Table 14.8.1 Ship motions

Motion	Maximum single amplitude	Periods, in seconds
Roll	ϕ = $\sin^{-1}\theta$ degrees but need not exceed 30° and is not to be taken less than 22° where $\theta = \sin\phi$ $= \left(0{,}45 + 0{,}1\,\dfrac{L}{B}\right)\left(0{,}54 - \dfrac{L}{1270}\right)$	$T_r = \dfrac{0{,}7B}{\sqrt{GM}}$
Pitch	$\psi = 12e^{-0{,}0033L_{pp}}$ but need not exceed 8°	$T_p = 0{,}5\sqrt{L_{pp}}$
Heave	$\dfrac{L_{pp}}{80}$ m	$T_h = 0{,}5\sqrt{L_{pp}}$

8.1.5 Wind forces are to be taken as acting athwartships on the exposed faces of the container stack so as to increase the transverse force. Where the air gap between adjacent rows of containers does not exceed one metre, wind forces on the adjacent inner stack may be taken as zero. Where the air gap is five metres or more, the adjacent inner stack is to be treated as fully exposed. Wind forces on the inner stack for intermediate air gaps may be obtained by linear interpolation.

8.1.6 The individual components of force due to gravity, wind and ship motions acting on a particular container are to be determined in accordance with Table 14.8.2~~ for the specified load cases~~.

~~*8.1.7* The individual components of acceleration due to ship motions on a container are:~~

- ~~Sliding (Longitudinal)~~

  ~~$a_x = C_{xS}\,a_{surge} + C_{xP}\,a_{pitch}\,z_1 - C_{xG}\,g\,\sin\psi$~~

- ~~Sliding (Transverse)~~

  ~~$a_y = C_{yS}\,a_{sway} - C_{yR}\,a_{roll}\,z_1 + C_{yG}\,g\,\sin\phi$~~

- ~~Compression (Vertical)~~

  ~~$a_z = C_{p1}\,(C_{zH}\,a_{heave} + C_{zR}\,a_{roll}\,y_1 - C_{zP}\,a_{pitch}\,x_1)$~~

~~Load combination factors C_{xS}, C_{xP}, C_{xG}, C_{yS}, C_{yR}, C_{yG}, C_{zH}, C_{zR} and C_{zP} for each load case are given in Tables 14.8.3 and 14.8.4.~~

~~C_{p1} for LC1 is given in Fig. 14.1.1. For other load cases the value of C_{p1} is to be taken as 1,0.~~

~~*8.1.8*~~ *8.1.7* Forces due to pretensioning the securing devices need not, in general, be included in the calculation provided they do not exceed 5 kN in any one item. Special consideration will be given to cases where forces obtained from pre-stressing are an integral part of the design of the system.

~~*8.1.9*~~ *8.1.8* For ships having the class notation **Container Ship**, an effective breakwater is to be fitted to protect the containers against green sea impact loads. For other ships which are equipped for the carriage of containers on deck, protection of the cargo is recommended by the provision of a breakwater.

~~*8.1.10*~~ *8.1.9* Consideration is to be given to the forces from wave impact and shipping green seas where the form and proportions of the ship are such that these may occur. In general the strength of containers and the strength of the securing arrangements in the forward $0{,}25L_{pp}$ are to be suitable for forces increased by 20 per cent above the values calculated from these requirements. The increase of forces is to be applied to the outer exposed containers.

8.2 Resultant forces

8.2.1 The resultant force acting on the container is the vectorial summation of the individual directional components of all forces acting at a given instant, *see* Fig. 14.8.2. The securing system is to be designed on the basis of the most severe combination of these forces in such a manner that the forces on the containers and securing devices are within allowable limits. Where different arrangements of securing devices are proposed for different locations on the ship, the forces are to be calculated for the most severe condition applicable to each arrangement.

~~*8.2.2* The resultants in each of the three co-ordinate axes defined in Fig. 14.1.2 are to be derived from the individual components of force determined from Table 14.8.2 for the load cases given in 8.2.3.~~

8.2.2 The instantaneous maximum value of the resultants of the forces depends upon the phase relationship between the ship motions. This relationship may be derived from model testing where carried out for the specific ship, from ship motion analysis or from full scale measurements if carried out for a ship of similar geometry.

~~**Table 14.8.2 Components of forces**~~

~~Load case~~	~~Components of forces, in kN~~				
	~~Ship motion induced force~~			~~Wind and gravity forces~~	
	~~Sliding, J_{DY} (longitudinal, parallel to deck)~~	~~Sliding H_{DY} (transverse, parallel to deck)~~	~~Compression, P_{DY} (normal to deck)~~	~~Wind, Q (transverse, parallel to deck)~~	~~Compression, P_{GW} (normal to deck)~~
~~LC1~~	~~Wa_x~~	~~Wa_y~~	~~Wa_z~~	~~$2{,}75A\,V_w{}^2 \times 10^{-4}$~~	~~$Wg \cos \psi$~~
~~LC2~~	~~Wa_x~~	~~Wa_y~~	~~Wa_z~~	~~$8{,}25A\,V_w{}^2 \cos^2 \phi \times 10^{-4}$~~	~~$Wg \cos \phi$~~
~~LC3~~	~~Wa_x~~	~~Wa_y~~	~~Wa_z~~	~~$7{,}18A\,V_w{}^2 \times 10^{-4}$~~	~~$Wg \cos \psi$~~
~~LC4~~	~~Wa_x~~	~~Wa_y~~	~~Wa_z~~	~~$4{,}13A\,V_w{}^2 \cos^2 \phi \times 10^{-4}$~~	~~$Wg \cos \phi$~~
~~LC5~~	~~Wa_x~~	~~Wa_y~~	~~Wa_z~~	~~$8{,}00A\,V_w{}^2 \times 10^{-4}$~~	~~$Wg \cos \psi$~~

~~NOTES~~
1. ~~For definition of terms, *see* 1.4.1 and Fig. 14.8.1.~~
2. ~~For definition of load cases, *see* 8.2.3.~~
3. ~~For definition of a_x, a_y and a_z, *see* 8.1.7.~~
4. ~~The forces caused by heeling of a ship in port are to be specially considered.~~
5. ~~The appropriate signs are to be used in calculating components of forces.~~

Table 14.8.2 Components of forces

Source	Component of force, in kN		
	Compression (normal to deck)	Sliding (parallel to deck)	
		transverse	longitudinal
STATIC			
Roll	$Wg \cos \phi$	$Wg \sin \phi$	
Pitch	$Wg \cos \psi$		$Wg \sin \psi$
Combined	$Wg \cos (0{,}71\phi) \cos (0{,}71\psi)$	$Wg \sin (0{,}71\phi)$	$Wg \sin (0{,}71\psi)$
DYNAMIC			
Roll	$0{,}07Wg \dfrac{\phi}{T_r{}^2}\, y$	$0{,}07Wg \dfrac{\phi}{T_r{}^2}\, z_m$	
Pitch	$0{,}07Wg \dfrac{\psi}{T_p{}^2}\, x$		$0{,}07Wg \dfrac{\psi}{T_p{}^2}\, z_m$
Heave:			
Roll	$0{,}05Wg \dfrac{L_{pp}}{T_h{}^2} \cos \phi$	$0{,}05Wg \dfrac{L_{pp}}{T_h{}^2} \sin \phi$	
Pitch	$0{,}05Wg \dfrac{L_{pp}}{T_h{}^2} \cos \psi$		$0{,}05Wg \dfrac{L_{pp}}{T_h{}^2} \sin \psi$
WIND		Roll $8{,}25AV_W{}^2 \cos^2 \phi \times 10^{-4}$ Pitch $8{,}25AV_W{}^2 \times 10^{-4}$ Combined $8{,}25AV_W{}^2 \cos^2 (0{,}71\phi) \times 10^{-4}$	

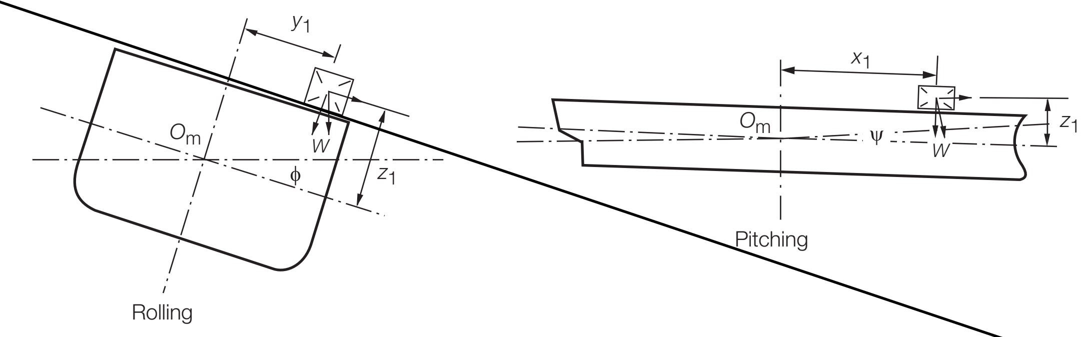
NOTES
1. For definition of terms, *see* 1.4.1 and Fig. 14.8.1.
2. The appropriate signs are to be used in calculating vector components of forces.

~~Table 14.8.3~~ ~~Load combination factors (LCFs) for head sea and beam sea cases~~

Load case			LC1		LC2			
Heading			Head		Beam			
Incoming wave			From bow		From port side		From starboard side	
		LCF	HS_1	HS_2	BS_1P	BS_2P	BS_1S	BS_2S
Longitudinal accelerations	a_{surge}	C_{xS}	–0,69	0,69	0	0	0	0
	a_{pitch}	C_{xP}	f_{ap}	$-f_{ap}$	0	0	0	0
	$g \sin\psi$	C_{xG}	–0,85	0,85	0	0	0	0
Transverse accelerations	a_{sway}	C_{yS}	0	0	–0,09	0,09	0,09	–0,09
	a_{roll}	C_{yR}	0	0	0,66	–0,66	–0,66	0,66
	$g \sin\phi$	C_{yG}	0	0	–0,66	0,66	0,66	–0,66
Vertical accelerations	a_{heave}	C_{zH}	–0,18	0,18	0,14	–0,14	0,14	–0,14
	a_{roll}	C_{zR}	0	0	0,66	–0,66	–0,66	0,66
	a_{pitch}	C_{zP}	f_{ap}	$-f_{ap}$	0	0	0	0

~~Table 14.8.4~~ ~~Load combination factors (LCFs) for oblique cases~~

Load case			LC3				LC4				LC5			
Incoming wave			From port side		From starboard side		From port side		From starboard side		From port side		From starboard side	
		LCF	OS1_1P	OS1_2P	OS1_1S	OS1_2S	OS2_1P	OS2_2P	OS2_1S	OS2_2S	OS3_1P	OS3_2P	OS3_1S	OS3_2S
Londitudinal accelerations	a_{surge}	C_{xS}	–0,43	0,43	–0,43	0,43	0	0	0	0	0,62	–0,62	0,62	–0,62
	a_{pitch}	C_{xP}	1,0	–1,0	1,0	–1,0	0	0	0	0	–0,46	0,46	–0,46	0,46
	$g \sin\psi$	C_{xG}	–0,86	0,86	–0,86	0,86	0	0	0	0	0,65	–0,65	0,65	–0,65
Transverse accelerations	a_{sway}	C_{yS}	–0,28	0,28	0,28	–0,28	0	0	0	0	0,96	–0,96	–0,96	0,96
	a_{roll}	C_{yR}	–0.22	0,22	0,22	–0,22	1,0	–1,0	–1,0	1,0	–0,36	0,36	0,36	–0,36
	$g \sin\phi$	C_{yG}	0,05	–0,05	–0,05	0,05	–1,0	1,0	1,0	–1,0	0,12	–0,12	–0,12	0,12
Vertical accelerations	a_{heave}	C_{zH}	–0,29	0,29	–0,29	0,29	0	0	0	0	0,11	–0,11	0,11	–0,11
	a_{roll}	C_{zR}	0,05	–0,05	–0,05	0,05	0	0	0	0	–0,36	0,36	0,36	–0,36
	a_{pitch}	C_{zP}	1,0	–1,0	1,0	–1,0	0	0	0	0	–0,46	0,46	–0,46	0,46



~~**Fig. 14.8.1 Diagrammatic representation of symbols used in Table 14.8.2**~~

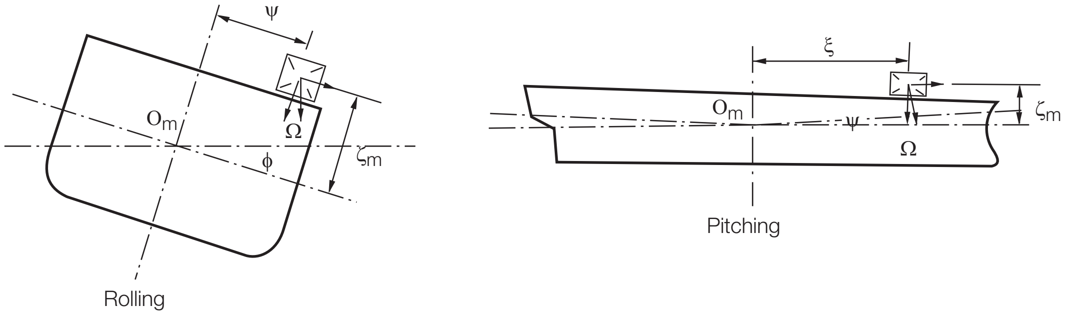


Fig. 14.8.1 Diagrammatic representation of symbols used in Table 14.8.2

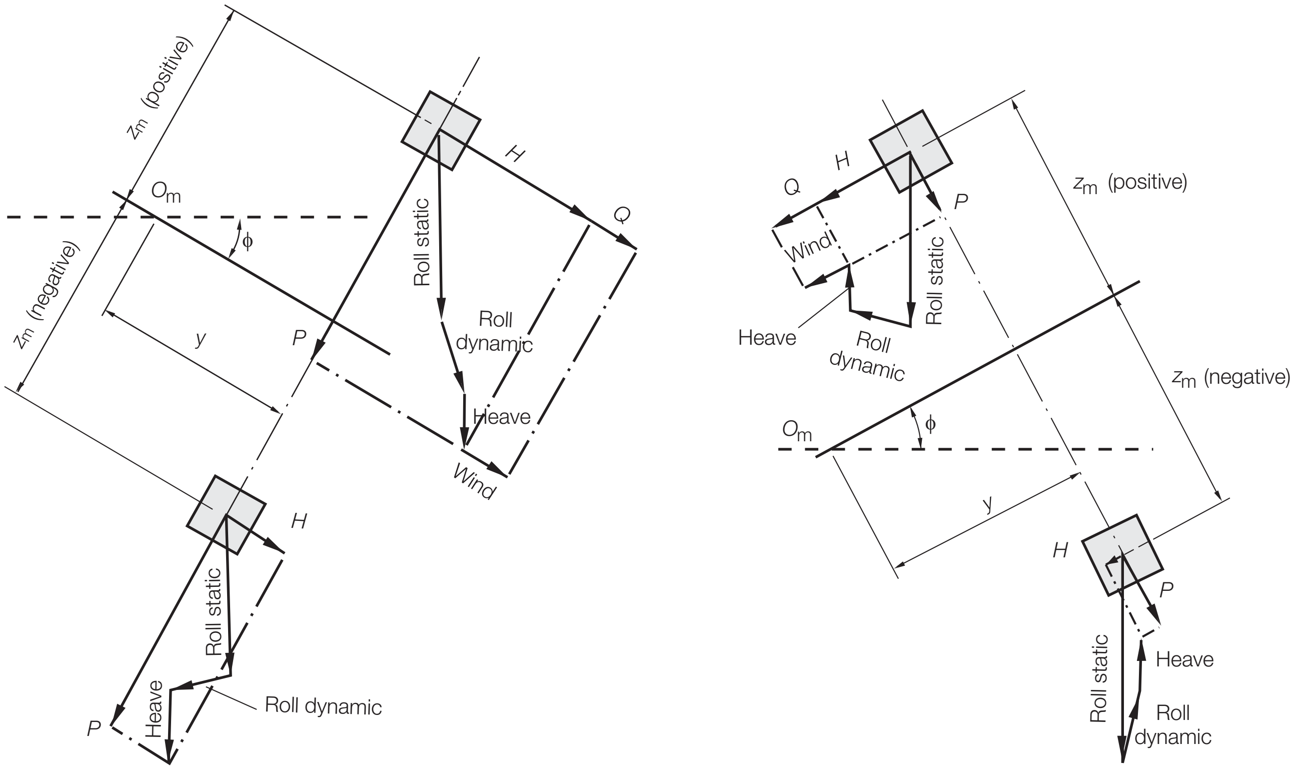


Fig. 14.8.2 Components of force on one container (Rolling condition)

~~*8.2.3* The Load Combination Factors (LCFs) given in Tables 14.8.3 and 14.8.4 are to be used, in which regular waves that generate response values equivalent to the long-term response values of the load components considered are set as Equivalent Design Waves (EDWs). The following five sets of load cases (LCs) are to be considered:~~

~~**LC1:**~~
~~in a head sea when the vertical acceleration becomes maximum;~~
~~**LC2:**~~
~~in a beam sea when the roll motion becomes maximum;~~
~~**LC3:**~~
~~when the pitch acceleration becomes maximum in an oblique sea;~~
~~**LC4:**~~
~~when the roll motion becomes maximum in an oblique sea with forward speed;~~
~~**LC5:**~~
~~combined condition of transverse and vertical accelerations in an oblique sea.~~

8.2.3 Alternatively, the resultants in each of the three co-ordinate axes may be derived from the individual components of force determined from Table 14.8.2 for the instantaneous positions in the motion cycle as follows:

(a) Rolling condition:
  (i) Maximum roll (descending) with maximum heave (descending).
  (ii) Maximum roll (ascending) with maximum heave (ascending).
(b) Pitching condition:
  (i) Maximum pitch (descending) with maximum heave (descending).
  (ii) Maximum pitch (ascending) with maximum heave (ascending).
(c) Combined condition:
  (i) 0,71 [Maximum roll (descending) with maximum pitch (descending)].
  (ii) 0,71 [Maximum roll (ascending) with maximum pitch (ascending)].

~~*8.2.4* The summation of the individual components of force for each container is obtained to give the following resultants:~~

- ~~Sliding (Longitudinal)~~
  ~~$J = J_{DY}$~~
- ~~Sliding (Transverse)~~
  ~~$H = H_{DY}$~~
- ~~Compression (Vertical)~~
  ~~$P = P_{DY} + P_{GW}$~~

~~J_{DY}, H_{DY}, P_{DY}, H_{GW} and P_{GW} are to be calculated in accordance with Table 14.8.2. The maximum and minimum values of force are determined from the calculated resultants.~~

8.2.4 The summation of the individual components of force for one container above or below the centre of motion is shown for the Rolling condition in Fig. 14.8.2, and the resultants are obtained from the following expressions:

(a) Bottom of motions, *see* 8.2.3 (a)(i):
Compression

$$P_{max} = Wg\left[\left(1 + \frac{0{,}05L_{pp}}{T_h^2}\right)\cos\phi + \frac{0{,}07\phi}{T_r^2}\, y\right]$$

Sliding (transverse)

$$H_{max} = Wg\left[\left(1 + \frac{0{,}05L_{pp}}{T_h^2}\right)\sin\phi + \frac{0{,}07\phi}{T_r^2}\, z_m\right]$$

(b) Top of motions, *see* 8.2.3(a)(ii):
Compression

$$P_{min} = Wg\left[\left(1 - \frac{0{,}05L_{pp}}{T_h^2}\right)\cos\phi - \frac{0{,}07\phi}{T_r^2}\, y\right]$$

Sliding (transverse)

$$H_{min} = Wg\left[\left(1 - \frac{0{,}05L_{pp}}{T_h^2}\right)\sin\phi + \frac{0{,}07\phi}{T_r^2}\, z_m\right]$$

The corresponding summations for the Pitching and Combined conditions may be written similarly.

■ *Section 9*
Strength of container securing arrangements

9.1 Resultant applied forces

9.1.1 The resultant forces derived for each container in the stack in accordance with Section 8 are assumed to be divided equally between the walls of the container as follows:

H_i = sliding force in one transverse end = $\frac{H}{2}$ kN

J_i = sliding force in one longitudinal side = $\frac{J}{2}$ kN

P_i = vertical force in each corner post = $\frac{P}{4}$ kN

Q_i = wind force in one transverse end = $\frac{Q}{2}$ kN

The subscript i refers to any particular container.

9.1.2 The sliding forces H_i and J_i are taken to act at one third the height of the container above its base. That is, the force may be distributed as to $\frac{H_i}{3}\left(\text{or } \frac{J_i}{3}\right)$ acting at the top of the container and $\frac{2H_i}{3}\left(\text{or } \frac{2J_i}{3}\right)$ acting at the bottom, *see* Fig. 14.9.1.

9.1.3 Wind force is taken as uniformly distributed over the side of the container and is therefore divided equally between the top and bottom of the container, *see* Fig.14.9.1.

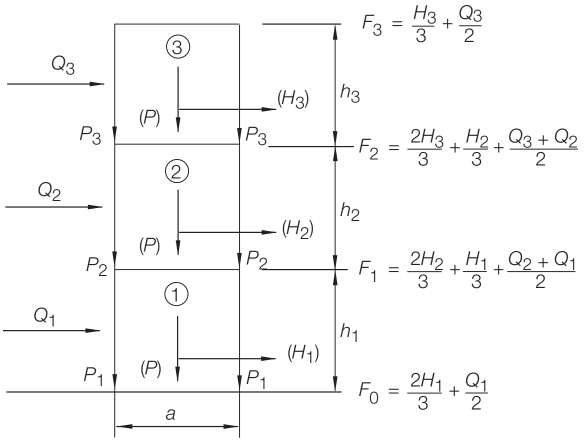

$F_3 = \frac{H_3}{3} + \frac{Q_3}{2}$
③
Q_3
(H_3)
h_3
(P)
P_3
P_3
$F_2 = \frac{2H_3}{3} + \frac{H_2}{3} + \frac{Q_3 + Q_2}{2}$
②
Q_2
h_2
(H_2)
(P)
P_2
P_2
$F_1 = \frac{2H_2}{3} + \frac{H_1}{3} + \frac{Q_2 + Q_1}{2}$
①
Q_1
h_1
(H_1)
P_1
(P)
P_1
$F_0 = \frac{2H_1}{3} + \frac{Q_1}{2}$
a

Fig. 14.9.1
Forces in a three tier stack (Rolling condition)

9.2 Forces in an unlashed stack

9.2.1 Where the stack is supported only by approved devices between the tiers of containers and at the base of the stack, the forces in the stack are determined from Table 14.9.1.

9.2.2 To illustrate this calculation, the equations for the three tier stack shown in Fig. 14.9.1 are listed below for the Rolling condition. In these equations the values of P and H are the maxima or minima derived from 8.2.4 as appropriate. Similar equations may be written for the Pitching and for the Combined conditions.

(a) Racking force, per end wall:
  Tier 3: F_3
  Tier 2: $F_3 + F_2$
  Tier 1: $F_3 + F_2 + F_1$
(b) Shear force, per corner:
  Tier 3: 0,55 $(H_3 + Q_3)$
  Tier 2: 0,55 $(H_3 + H_2 + Q_3 + Q_2)$
  Tier 1: 0,55 $(H_3 + H_2 + H_1 + Q_3 + Q_2 + Q_1)$

Table 14.9.1 Forces in an unlashed stack

Force, in kN	Symbol	Expression	Remark
Racking force per corner wall:			
Transverse	RA_{yi}	$RA_{yi} = \sum_{j=i}^{n} F_j$	n: total numbers of tiers
Longitudinal	RA_{xi}	$RA_{xi} = \sum_{j=i}^{n} G_j$	
Shear force per corner:			
Transverse	SF_{yi}	$SF_{yi} = 0{,}55 \sum_{j=i}^{n} (H_j + Q_j)$	Q_j: exposed stack only
Longitudinal	SF_{xi}	$SF_{xi} = 0{,}55 \sum_{j=i}^{n} J_j$	
Vertical reaction to tipping per corner:			
Transverse	V_{yi}	$V_{yi} = \frac{1}{a} \sum_{j=i}^{n} F_j z_j$	*See* Notes 1 and 2
Longitudinal	V_{xi}	$V_{xi} = \frac{1}{b} \sum_{j=i}^{n} G_j z_j$	*See* Notes 1 and 2
Vertical pressure per corner	VP_i	$VP_i = \sum_{j=i}^{n} P_j$	*See* Note 2
Resultant compressive force per corner:			
Maximum transverse		VP_i max. + V_{yi} max.	*See* Note 3
Minimum transverse		VP_i max. – V_{yi} max. or VP_i min. – V_{yi} min.	
Maximum longitudinal		VP_i max. + V_{xi} max.	*See* Note 3
Minimum longitudinal		VP_i max. – V_{xi} max. or VP_i min. – V_{xi} min.	

NOTES
1. z_j is the distance from the level under consideration to the top of each container above that level, in metres.
2. Both the maximum and the minimum values are to be calculated.
3. Whichever is the lesser. A negative value induces separation.

(c) Maximum compressive force per bottom corner (i.e. force on the container below):

Tier 3: $P_3 + \frac{F_3}{a} h_3$

Tier 2: $P_3 + P_2 + \frac{F_3}{a} (h_3 + h_2) + \frac{F_2}{a} h_2$

Tier 1:

$$P_3 + P_2 + P_1 + \frac{F_3}{a}(h_3 + h_2 + h_1) + \frac{F_2}{a}(h_2 + h_1) + \frac{F_1}{a} h_1$$

(d) Minimum compressive force per bottom corner:
Case (i) (maximum amplitude descending):

Tier 3: $P_3 - \frac{F_3}{a} h_3$

Tier 2: $P_3 + P_2 - \frac{F_3}{a} (h_3 + h_2) - \frac{F_2}{a} h_2$

Tier 1:

$$P_3 + P_2 + P_1 - \frac{F_3}{a}(h_3 + h_2 + h_1) - \frac{F_2}{a}(h_2 + h_1) - \frac{F_1}{a} h_1$$

Case (ii) (maximum amplitude ascending):

Tier 3: $P_3 - \frac{F_3}{a} h_3$

Tier 2: $P_3 + P_2 - \frac{F_3}{a} (h_3 + h_2) - \frac{F_2}{a} h_2$

Tier 1:

$$P_3 + P_2 + P_1 - \frac{F_3}{a}(h_3 + h_2 + h_1) - \frac{F_2}{a}(h_2 + h_1) - \frac{F_1}{a} h_1$$

A negative value in these equations indicates a separation force at that level. The minimum is the lesser value from the two cases.

9.2.3 The resultant forces calculated from 9.2.1 are not to exceed the allowable loads for which the container is suitable, *see* 9.7.

9.2.4 The resultant forces in the securing devices and supports are not to exceed the allowable working loads for which the device has been approved, *see* Sections 2 and 3.

9.2.5 For exposed stacks in the forward 0,25L_{pp}, *see* 8.1.10.

9.3 Arrangements incorporating lashings

9.3.1 Where the securing arrangements incorporate lashings, proper allowance is to be made for flexibility of the system. For this purpose, the following values may be adopted:

(a) **Racking deformation of the container.** Full scale testing of containers indicates that values of the spring constant (*see* Fig. 14.9.3) may be taken as in Table 14.9.2.

(b) **Horizontal movement of the containers.** Initial displacement of containers due to tolerances in container fittings will be considered in conjunction with the stowage arrangement proposed. Generally, initial displacement may be neglected in calculation procedures for conventional stowages.

(c) **Elongation of lashings.** Elongation is to be determined by reference to the effective modulus of elasticity of the lashing (allowance for straightening and stretching) which, in the absence of actual test values, may be taken as:

steel rod lashings of hook	98 kN/mm^2
type turnbuckle short (one tier) steel	140 kN/mm^2
rod lashings (knob type), incl. turnbuckle and lashing eyes long (two tier) steel	175 kN/mm^2
rod lashings (knob type), incl. turnbuckle and lashing eyes steel wire rope lashings	90 kN/mm^2
steel chain lashings (based on the nominal diameter of the chain)	80 kN/mm^2
Adjustable tension/ compression buttress	120 kN/mm^2
Aluminium or other materials	To be considered.

Table 14.9.2 Spring constants for containers

Height (m)	Door end kN/mm	Closed end kN/mm
2,438	03,7	16,7
2,591	03,5	15,4
2,743	03,3	14,3
2,896	03,2	13,3

9.3.2 Any other element introducing flexibility into the structure between the lashing point and the base of the container stack is to be evaluated and taken into account, if necessary. Examples of this could be flexibility of a lashing bridge, sliding of a hatch cover, or torsional deformations of the hull.

9.3.3 When paired lashings (para-lash arrangements) are used, for the purpose for lashing calculations a cross-sectional area equal to 150 per cent of the cross-sectional area of one lashing is to be used.

9.3.4 The resultant applied forces are determined in accordance with 9.1. The distribution of forces in the stack is obtained by equating the total movement of the containers with the corresponding component of elongation of the associated support element under the influence of the imposed forces.

9.3.5 The calculations are to be made for each end of the container stack, that is with all door ends together and with all closed ends together.

9.3.6 The load system for a four tier stack of containers with upper and lower lashings is illustrated in Fig. 14.9.2. The containers and lashings are modeled as a system of springs whose stiffness may be calculated and hence the equilibrium condition for the system may be found, *see* Fig. 14.9.3.

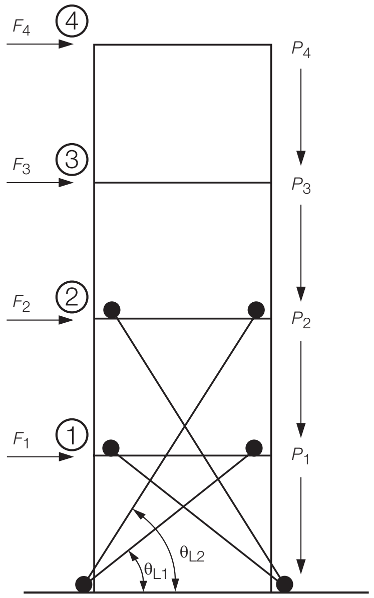


Fig. 14.9.2 Container stack load system

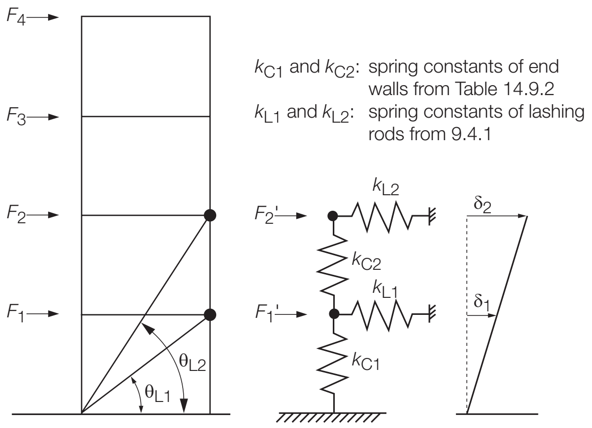

F_4
F_3
F_2
F_1
k_{C1} and k_{C2}: spring constants of end walls from Table 14.9.2
k_{L1} and k_{L2}: spring constants of lashing rods from 9.4.1
F_2'
F_1'
k_{L2}
k_{C2}
k_{L1}
k_{C1}
δ_2
δ_1
θ_{L2}
θ_{L1}

Fig. 14.9.3 Container stack load system

9.3.7 Having established the tension in the lashings, the residual forces in the containers are transmitted through the stack in accordance with the method given in 9.5. The model assumes that the securing devices between tiers of containers are capable of resisting negative (separation) forces. That is, where separation forces are found, suitable locking devices are assumed to be fitted and transmitting load.

9.3.8 A buttress or shore may be modeled in a similar way to a lashing. Where, however, more than one stack is supported by the use of linkages between adjacent containers in line with the buttress or shore, the model is to take this into account.

9.4 Tensions in the lashing rods

9.4.1 For conventional arrangements, the spring constant for the lashing rod may be determined using the expression:

$$k_L = \frac{E\,A\,\mathrm{Cos}^2\,\theta_L}{l_L}$$

However, some stowage arrangements may result in considerable longitudinal displacement between the base of the lashing and the fitting in the container corner, i.e. 40 ft container in a 45 ft bay. In such cases the spring constant of the lashing rod should be determined using the following expression:

$$k_L = \frac{E\,A\,l_y^2}{l_L^3}$$

where

E = Effective Modulus of Elasticity (kN/mm^2)
A = cross-section area of lashing rod, in mm^2
l_L = length of lashing (mm) given by
$l_L = \sqrt{l_x^2 + l_y^2 + l_z^2}$
l_x = longitudinal separation of lashing ends measured parallel to ship's X axis, in mm
l_y = transverse separation of lashing ends measured parallel to ship's Y axis, in mm
l_z = vertical separation of lashing ends measured parallel to ship's Z axis, in mm
θ_L = lashing angle, in degrees.

In case of the aforementioned configuration, attention is to be paid to the fact that the arrangement of the fixed lashing plates is to be suitable to accommodate the inclined lashing rods. In addition, attention should be paid to the design of the heads of the lashing rods being suitable to secure the container under the angle of inclination.

9.4.2 The expressions for the tensions in the lashing rods will vary with the lashing arrangement used, however, for the three cases below the expressions for the lashing rod tensions are summarised in Table 14.9.3:

(a) Single cross lashed stack.
(b) Double cross lashed stack.

9.5 Residual forces

9.5.1 The residual transverse force in the containers at the level of the lashing is:

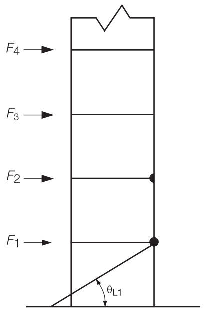
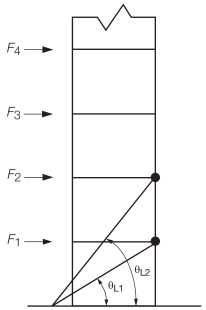
Lower $F_{1,RES} = F_1 - T_{L1} \cos\theta_{L1}$ (kN)
Upper $F_{2,RES} = F_2 - T_{L2} \cos\theta_{L2}$ (kN)

The racking and shearing forces in the container stack may then be determined in accordance with 9.2.2 using the residual transverse forces. The maximum and minimum vertical forces in the corner posts may be determined similarly taking due account of the vertical component of lashing tension where applicable.

9.5.2 The resultant forces in the containers are not to exceed the allowable values given in 9.7.

9.5.3 The lashing tensions are not to exceed the allowable working loads of the lashings as determined from Section 3.

Table. 14.9.3 Lashing rod tensions and residual forces calculation

Arrangement	F'_x	Tension in lashing	Residual transverse Forces at lashing level
	$F'_1 = \sum_{i=1}^{n} F_i$	$T_{L1} = \dfrac{k_{L1} F'_1}{(k_{C1} + k_{L1}) \cos\theta_{L1}}$	$F_{1,RES} = F_1 - T_{L1} \cos\theta_{L1}$
 F_4 F_3 F_2 F_1 θ_{L2} θ_{L1}	$F'_2 = \sum_{i=2}^{n} F_i$	$T_{L1} = \dfrac{k_{L1}}{\cos\theta_{L1}} \dfrac{(k_{C2} + k_{L2}) F'_1 - k_{L2} F'_2}{(k_{C1} + k_{L1})(k_{C2} + k_{L2}) + k_{C2} k_{L2}}$ $T_{L2} = \dfrac{k_{L2}}{\cos\theta_{L2}} \dfrac{k_{C2} F'_1 + (k_{C1} + k_{L1}) F'_2}{(k_{C1} + k_{L1})(k_{C2} + k_{L2}) + k_{C2} k_{L2}}$	$F_{1,RES} = F_1 - T_{L1} \cos\theta_{L1}$ $F_{2,RES} = F_2 - T_{L2} \cos\theta_{L2}$

9.5.4 Where external support is provided by a buttress or shore the load is to be transmitted between adjacent stacks by linkages in line with the support. The force in the transverse end frame members of the containers adjacent to the support is given by:

$F_b\left(\frac{2N-1}{2N}\right)$ kN and the force in the linkage to the adjacent container is $F_b\left(\frac{N-1}{N}\right)$ kN

where

F_b = calculated force in the buttress or shore, in kN

N = number of rows of containers supported by the buttress or shore.

9.6 Structural restraint systems

9.6.1 Where open framework systems are fitted on deck to provide structural restraint, they are to be designed to absorb the full horizontal component of force at that level and to prevent movement of the container stack. For the purpose of these calculations the deformation of the ship's structure in way of supports may be neglected.

9.7 Allowable forces on containers

9.7.1 For ISO containers, the securing arrangements are to be designed so that the forces on the containers do not exceed the values shown in Table 14.9.4. The maximum forces for ISO 1496-1: 1990 including Amendment Nos. 1, 2 and 3 containers are illustrated in Fig. 14.9.4. Proposals to carry out the lashing calculations for containers manufactured in accordance with ISO 1496-1:1990/Amendment No. 4, 2006 will be specially considered.

9.7.2 The allowable forces for containers of other dimensions, e.g. 24 ft, 48 ft and 53 ft, will be determined on the basis of the values in Table 14.9.4 and of the forces for which the container has been certified.

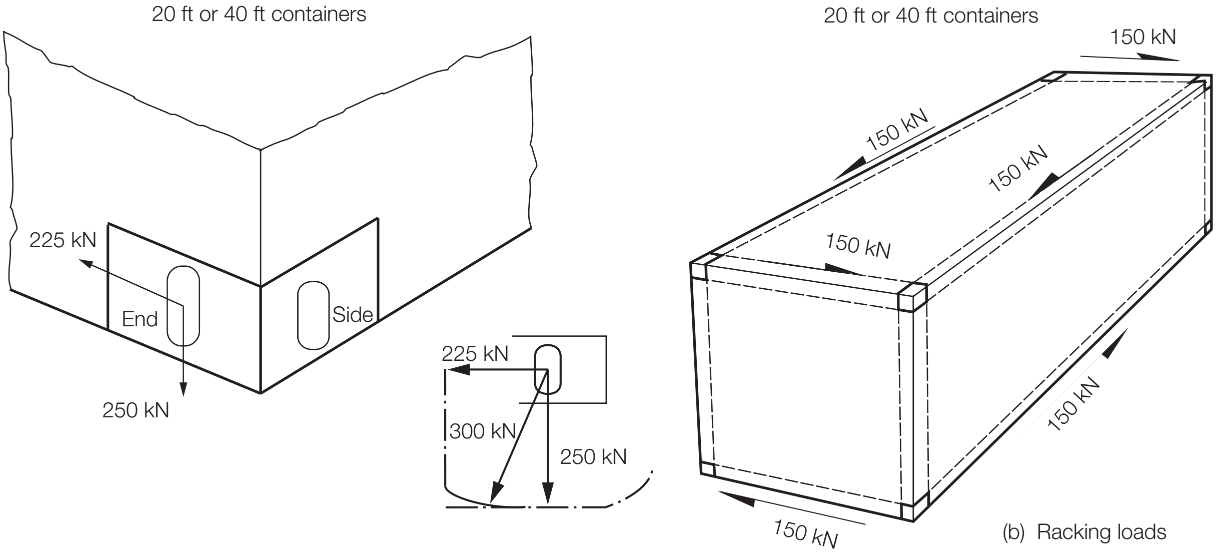
9.7.3 Where 45 ft containers in accordance with ISO 1496-1:1990/Amd.4, 2006 are stowed on top of a 40 ft container, the corner post load of the top castings of the 45 ft container are not to exceed a compression force of 404 kN. Consideration should be given to the strength of the container bottom structure to withstand the forces transmitted. No lashings are to be applied to the ends of the 45 ft container if stowed on top of a 40 ft unit.

Table 14.9.4 Allowable forces on ISO containers

	ISO 1496-1:1990 including up to Amendment No. 3 20 ft	 40 ft
	in kN	
Horizontal force from a container fitting acting parallel to the side face	150	150
Horizontal force from lashing on container fitting acting parallel to the end face, *see* Note 1	225	225
Vertical force from lashing on container fitting acting parallel to the end or side face, *see* Note 1	250	250
Racking force on container end	150	150
Racking force on container side	150	150
Vertical forces at each top corner, tension	250	250
Vertical forces at each bottom corner, tension	250	250
Vertical forces at each top corner post, compression	848	848
Vertical force at each bottom corner casting of the lowest container in a stack, compression	848 + (1,8Rg)/4 *see* Note 3	848 + (1,8Rg)/4 *see* Note 3
Transverse forces acting at the level of and parallel to the top face, tension or compression, *see* Note 2	340	340
Transverse forces acting at the level of and parallel to the bottom face, tension or compression, *see* Note 2	500	500

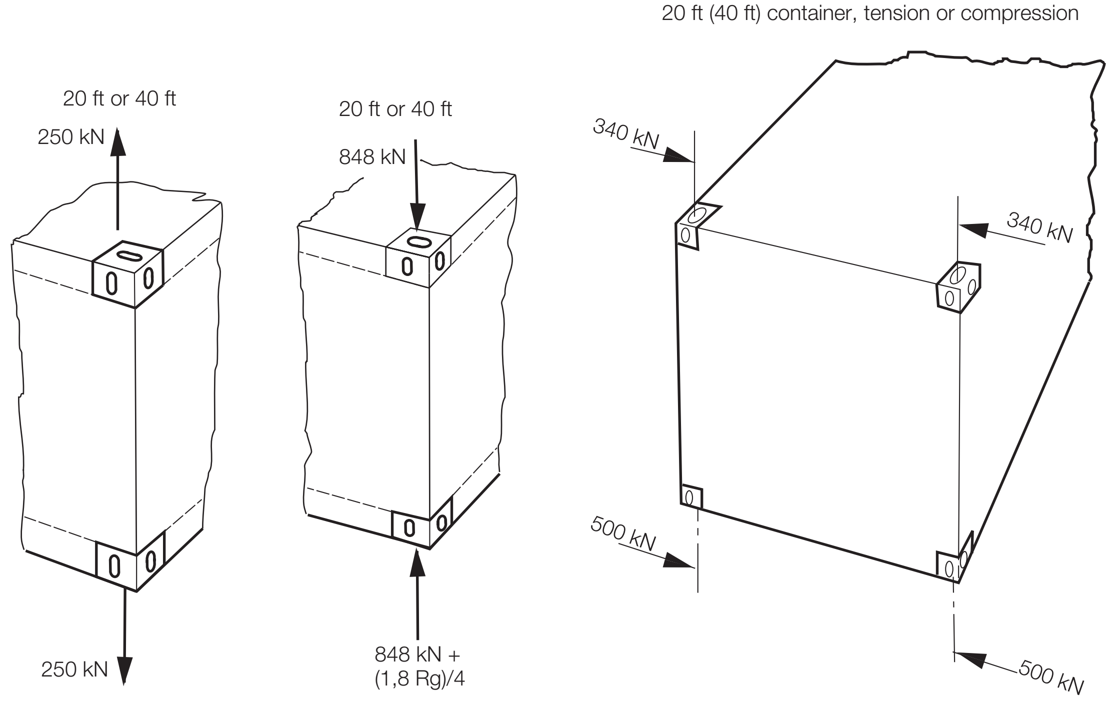
NOTES

1. In no case is the resultant of the horizontal and the vertical forces to exceed the limiting value derived from Fig. 14.9.4(a). The horizontal and vertical forces are the maximum components of a diagonal force and are not to be used as the maximum load if horizontal or vertical lashings are employed.
2. Where a buttress supports the stack at an intermediate level, the total transverse force in the containers at the level is not to exceed the sum of the appropriate top and bottom forces.
3. The vertical compression force on the lower corner casting on the closed end of the lowest container may exceed 848 + (1,8Rg/4) kN, provided the following conditions are complied with:
   (a) The vertical compression force acting on the lowest container from the container above does not exceed 848 kN.
   (b) The horizontal racking force acting on the lowest container from the container above does not exceed 150 kN.
   (c) The local ship side or hatch cover container foundation is designed and approved for the increased design compression force.
   (d) The loose bottom container securing fittings should have a contact area fulfilling the requirements of 3.2.4.



(b) Racking loads

(a) Corner casting lashing loads



(c) Vertical corner pull-out and compressive forces

(d) Transverse compressive forces

Fig. 14.9.4
Allowable forces for 20 ft or 40 ft containers construced to ISO 1496-1: 1990 including Amendment Nos. 1, 2 and 3

■ *Section 10*
Surveys

10.1 Initial Survey

10.1.1 The following requirements are mandatory for fixed fittings including cell guides, if fitted, on all ships. For ships having a **CCSA** class notation the requirements are also applicable for loose fittings.

10.1.2 The Surveyor is to be satisfied that the materials, workmanship and arrangements are satisfactory and in accordance with the requirements and the approved plans. Any items found not to be in accordance with the requirements or the approved plans, or any material, workmanship or arrangements found to be unsatisfactory are to be rectified.

10.1.3 A Register or plan is to be kept on board and up to date, and is to be made available to the Surveyor upon request. The Register or plans are to contain sufficient details to enable all fittings to be identified, including:

- a simple sketch;
- the name of the item;
- the number supplied;
- the manufacturer's mark or code; and
- the safe working load with the corresponding breaking load.

10.1.4 For container securing arrangements, a suitable container stowage arrangement plan is to accompany the Register. Where containers of types other than ISO containers are proposed to be carried, their stowage locations are to be clearly indicated on the plan.

10.1.5 The Register and stowage plans, if applicable, may be included in the Cargo Securing Manual.

10.2 Periodical Surveys

10.2.1 For the requirements for Periodical Surveys *see* Pt 1, Ch 3,2.2.40 and Pt 1, Ch 3,5.3.19.

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